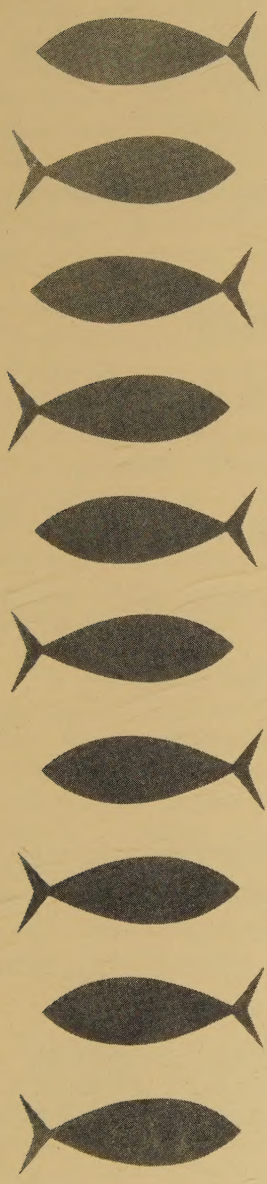
Southwest
FISHERIES SCIENCE CENTER

HONOLULU LA JOLLA MONTEREY TIBURON

REPORT OF ACTIVITIES May-June 1993



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ANTARCTIC ECOSYSTEM RESEARCH GROUP

La Jolla, California

Several Papers Completed on Field-season Findings

During May and June, the staff of the Antarctic Ecosystem Research Group (AERG) analyzed data collected during the 1992/93 and previous field seasons and produced a number of papers reporting their findings. Many of the papers were completed as part of the Antarctic Marine Living Resources (AMLR) Program's participation in the upcoming annual meetings of the Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR), in particular, the Working Groups on Krill (WG-Krill) and the CCAMLR Ecosystem Monitoring Program (WG-CEMP).

AERG's Fishery Biologist Roger Hewitt and Ocean Acoustics Engineer David Demer spent most of May and June in Antarctica aboard the National Science Foundation's research vessel (R/V) *Nathaniel B. Palmer*, conducting acoustic studies correlating krill distribution with bird densities and foraging behavior in the area around South Georgia Island. During the cruise, they also analyzed data collected from other cruises and produced several papers which will be delivered at the upcoming CCAMLR meetings.

The first paper that will be presented at the upcoming WG-Krill meeting is titled "Comparisons of krill densities as estimated from echo integration methods and fishery statistics" and is the result of collaboration between Hewitt, Demer, and Victor Marin, a Chilean scientist from Universidad de Chile de Santiago. In the paper, they compare krill density data taken during the AMLR 1991/92 season to data taken during the Chilean krill fishery from the same period.

In a second paper for the WG-Krill meeting, "Acoustic estimates of krill biomass in the Elephant Island area: 1981-1993," Hewitt and Demer responded to a CCAMLR Scientific Committee request to provide historical estimates of Elephant Island area krill biomass which have been adjusted to account for a new definition of krill target strength formulated at last year's meetings.

Demer and Hewitt's third paper to be presented at the WG-Krill meeting is titled "Bias in acoustic biomass estimates of *Euphausia superba* [Antarctic krill] due to diel migration." In it, they explain that studies conducted during the last two AMLR field seasons indicate that krill migrate to surface waters during dark hours and that this migration is likely to present a substantial bias to biomass estimates.

While at sea, Hewitt and Demer also put the final touches on a paper titled "Dispersion and abundance of Antarctic krill in the vicinity of Elephant Island in the 1992 austral summer," which has been accepted for publication in the *Marine Ecology Progress Series*.

For the upcoming WG-CEMP meeting, Hewitt and Demer, along with Donald Croll, formerly of the National Marine Mammal Laboratory, also worked on a paper titled "Penguin foraging behavior in relation to the distribution of prey." Their analyses have shown a strong correlation between penguin diving behaviors and krill diel migration patterns.

AERG's Biological Technician Jane Rosenberg compiled and edited the 1992/93 AMLR field season report, which fulfills a variety of post-cruise obligations. The report, which will be presented at the WG-CEMP meeting, includes a summary of research conducted during the 1993 cruise in the waters surrounding Elephant Island and at field stations on Seal Island and at Palmer Station. In addition, detailed summaries of 1993 AMLR research are included in the report.

AERG's Fishery Biologist George Watters worked on a number of papers for the upcoming November meeting of the Working Group on Fish Stock Assessment (WG-FSA). The papers focus on Antarctic crab, *Paralomis spinosissima*, which is the target of a new commercial fishery in the Antarctic. One paper concerns Watters' investigations into the parasitism of the crab by a rhizocephalan barnacle. From data collected during the last fishing season, it appears that, in some segments of the crab population, there are more parasitized individuals than nonparasitized individuals. Watters hypothesizes that the spatial heterogeneity of the distribution of parasitized crabs relative to the distribution of healthy crabs is what allows the population to persist. His paper will describe the spatial relationships between parasitized and nonparasitized crabs. Watters also attempted to identify the spatial and temporal scales that should be used to make reliable estimates of crab abundance; he plans to present a paper on this topic at the WG-FSA meeting. In addition, Watters worked on developing an

experimental management scheme for the harvest of Antarctic crabs.

Finally, the AMLR Program submitted a series of 10 papers to the *Antarctic Journal of the United States* for the 1993 review issue. Rosenberg, Hewitt, and AERG Chief Rennie Holt wrote a lead article for the series that gives a basic review of the AMLR Program and the 1992/93 field season. Hewitt and Demer wrote a paper for the series titled "AMLR Program: Distribution and abundance of krill in the vicinity of Elephant Island during the 1993 austral summer." This paper presents the results of data collected during six acoustic surveys conducted from mid-January to mid-March 1993. The results show that estimates of krill abundance decreased from 4.9 million tons to 3.2 million tons during the course of the season. The remaining eight papers, written by AMLR Program researchers, focus on individual components of the program such as physical oceanography, primary productivity, krill demography, and reproductive and foraging behaviors of penguins and seals. (J. Rosenberg, [619] 546-5600)

COASTAL FISHERIES RESOURCES DIVISION

La Jolla, California

Report Completed on Status of the California Coastal Pelagic Fisheries for 1992

Industry Economist Cynthia Thomson, Gregory Walls (California Department of Fish and Game, Long Beach), and James Morgan (NMFS Southwest Regional Office, Long Beach) have completed Southwest Fisheries Science Center Administrative Report LJ-93-14, "Status of the California coastal pelagic fisheries in 1992." The species covered by the report include Pacific sardine, *Sardinops sagax*; jack mackerel, *Trachurus symmetricus*; Pacific mackerel, *Scomber japonicus*; and northern anchovy, *Engraulis mordax*. The report describes the harvesting, processing, and export sectors of the U.S. commercial fishery, the U.S. recreational fishery, and the Mexican commercial fishery. The report also includes information on the historical development of the fishery as well as recent regulatory changes affecting the fishery.

California landings of Pacific sardine more than doubled from 7,750 metric tons (t) in 1991 to 18,525 t in 1992, largely as a result of industry response to an increase in the directed quota. This increase in sardine landings, however, did little to offset the industry's financial woes resulting from declining landings of other coastal pelagic species:

1. California landings of jack mackerel were lower in 1992 (613 t) than they have been since 1940.

2. Pacific mackerel landings totaled 17,802 t in 1992, the lowest level of landings since 1978.

3. The northern anchovy reduction fishery was closed in the 1992/93 season because of the low level of spawning biomass. Nonreduction landings of northern anchovy totaled 1,124 t in 1992, down by 65 percent from the 3,215 t harvested in 1991.

4. In recent years, the coastal pelagic fishing fleet has relied on market squid as well as coastal pelagics for much of its revenues. Market squid landings declined precipitously from 37,388 t in 1991 to 13,071 t in 1992.

5. In 1992 live bait catch of all species totaled 4,389 t, which was very similar to the annual average of 4,253 t experienced during 1974-1991. However, the contribution of northern anchovy to this harvest declined from an annual average of 97 percent during 1974-1991 to 59 percent in 1992, and bait haulers made up the slack created by poor anchovy availability with juvenile Pacific sardines.

6. Landings of Pacific mackerel by commercial passenger fishing vessels declined by almost 50 percent from an annual average of 817,026 fish during 1977-1987 to 401,349 fish during 1988-1992 while fishing effort remained virtually unchanged. Commercial passenger fishing vessels transport anglers to and from the fishing grounds and provide bait, food and beverage service, gear rental, and fish cleaning. Pacific mackerel harvest in 1992 was 325,892 fish, 26 percent lower than the 1991 harvest and the lowest harvest since 1976.

The low level of coastal pelagic landings in 1992 can be attributed to a number of factors. The Pacific mackerel population has been on a declining trend since 1988. The northern anchovy reduction fishery has been relatively inactive since 1983, when the ex-vessel (dock) price fell below $50/t, and the fishery has been closed in the past two seasons because of the low level of spawning biomass. El Niño conditions have displaced coastal pelagics and market squid to the north, diminishing availability to the traditional southern California fishery. A major Terminal Island cannery closed in mid-April of 1992 because of financial problems and reopened briefly

in October 1992, only to close its doors permanently in January 1993.

The coastal pelagic fishing fleet, defined here to include vessels that land at least 50 t of coastal pelagics during the year, has historically accounted for over 95 percent of total statewide landings of these species. Fleet size declined from 49 vessels in 1991 to 36 vessels in 1992. Average harvest per boat in 1992 was 1,252 t (all species) with a total ex-vessel value of $267,000. Harvest per boat was 14 percent lower than the 1991 average and 26 percent lower than the 1987-1991 average while average revenues were virtually the same as the 1991 level and 44 percent lower than the 1987-1991 average (Table 1).

Coastal pelagic processing plants, defined here as plants that receive at least 500 t of coastal pelagics during the year, have historically accounted for about 98 percent of total statewide receipts of these species. The 10 plants that met this 500 t criterion in 1992 received an average of 5,171 t of fish (all species) in 1992, 33 percent less than the average tonnage received in 1991 and 28 percent less than the average annual tonnage received during 1987-1991. About 73 percent of this total tonnage consisted of coastal pelagics and 10 percent consisted of market squid.

About 6,746 t of mackerel, 1,181 t of sardine, and 261 t of anchovy were exported from California in

Table 1. Average landings (t) and average ex-vessel revenues ($1,000s, base year=1992) per vessel by California round haul vessels landing at least 50 metric tons of coastal pelagics during the year, by species, 1981-1992. (Totals may not be exact due to rounding.)

Year	Northern Anchovy	Mackerel	Pacific Sardine	Market Squid	Pacific Herring	Bonito	Tuna	All Else	Total
Landings (metric tons)									
1981	899.4	909.8	0.3	135.9	12.6	94.1	33.9	1.6	2,087.6
1982	751.2	984.7	---	77.5	15.1	43.0	29.5	2.4	1,903.4
1983	21.7	831.2	---	9.9	11.9	61.8	43.5	3.2	983.2
1984	43.8	1,006.3	---	3.3	5.5	55.4	94.9	9.4	1,218.6
1985	26.1	970.8	0.1	137.3	9.3	60.8	43.1	2.6	1,249.3
1986	19.7	1,109.8	7.0	354.0	8.8	4.3	82.5	2.0	1,587.2
1987	25.1	1,100.0	7.9	275.7	10.6	87.4	27.9	4.9	1,539.5
1988	30.4	1,284.5	26.1	576.5	10.2	89.9	33.4	4.4	2,054.2
1989	47.0	1,249.5	15.6	514.5	12.1	22.1	22.7	3.1	1,886.7
1990	64.6	901.9	35.1	432.9	18.6	85.1	30.6	3.2	1,570.3
1991	74.1	655.6	146.5	533.1	14.1	10.5	2.3	21.4	1,457.6
1992	23.5	543.6	493.4	114.6	3.4	24.6	40.2	8.3	1,251.6
Ex-vessel Revenues ($1000s)									
1981	87.2	288.9	0.1	49.3	8.0	84.8	71.9	2.7	592.9
1982	51.3	289.5	---	20.7	7.4	27.6	51.1	1.8	449.3
1983	5.1	222.9	0.0	5.4	18.6	32.3	68.1	1.4	353.8
1984	4.2	251.2	---	2.2	2.3	20.9	157.1	4.4	442.4
1985	9.4	221.6	---	52.0	7.9	16.4	54.3	3.6	365.3
1986	3.1	293.6	1.8	100.1	7.3	1.4	192.6	3.5	603.3
1987	5.8	321.8	1.4	71.1	7.9	57.6	111.1	7.8	584.4
1988	9.2	253.3	4.6	138.0	5.0	47.4	161.3	4.0	622.8
1989	9.5	231.1	7.2	101.5	4.6	9.9	93.2	9.7	466.7
1990	30.0	208.2	5.0	76.4	12.3	43.3	68.9	16.4	460.4
1991	11.9	117.9	18.0	96.3	9.2	1.2	2.2	12.1	268.8
1992	5.7	140.5	48.5	21.7	3.0	11.7	29.0	6.9	267.0

--- denotes trace amount.

Source: Vessel summaries generated from California fish ticket data.

1992. The mackerel consisted largely of frozen products exported from Los Angeles, with the major recipients being South Korea and Fiji. Sardines were exported as frozen or prepared/preserved products, 53 percent of which went to the South Pacific (Western Samoa, Australia, and Fiji). The anchovy exports consisted largely of salted products exported from Los Angeles to Spain, Italy, and Portugal.

Northern anchovy (central subpopulation), Pacific sardine (northern subpopulation), and Pacific mackerel are harvested in Mexican as well as U.S. waters:

1. Mexican landings of northern anchovy surpassed U.S. landings during 1977-1989 and comprised more than 90 percent of combined landings of both countries during 1983-1989. During 1990-1992, Mexican landings fell to an average of 1,085 t per year, the lowest levels of harvest experienced since the inception of the fishery. The major reduction facility in Ensenada ceased operation in 1991.

2. Mexico's landings of Pacific sardine increased significantly during 1990-1992, averaging 22,371 t per year, as the population showed increasing signs of recovering from the collapse of the 1950s. The Mexican sardine harvest has consistently exceeded the U.S. harvest in the past three years.

3. U.S. landings of Pacific mackerel exceeded Mexican landings throughout the 1980s and into the 1990s. This trend was reversed in 1992, when U.S. landings declined sharply to 17,802 t, one-half the level of Mexico's 1992 landings (34,568 t).

A number of decisions have been made thus far in 1993 which will affect potential coastal pelagic harvests in 1993 and 1994:

1. The State of California has set a Pacific mackerel quota of 29,665 t for the 1993/94 season. This will be the second consecutive season in which a quota has been deemed necessary because of declining abundance.

2. Due to the low level of spawning biomass, the northern anchovy reduction fishery will be closed for the third consecutive season in 1993/94.

3. The Pacific sardine harvest during January-May of 1993 has been preliminarily estimated at 11,775 t. Several segments of the fishery have already closed for the season: the central California dead bait fishery on March 22, the southern California directed fishery on April 22, and the southern California dead bait fishery on May 24. A revised biomass estimate of 116,248 t was produced in June 1993, when complete 1992 data became available. It is not known at this time whether the 1993 quota will be modified as a result of this new estimate. (C. Thomson, [619] 546-7116)

Projection Made of Daily Population Growth of Northern Anchovy and Pacific Sardine Related to Duration Within Stage Using Stage-Specific Matrix Models

One method of assessing population growth is the matrix population model, which has been used in recent years to assess population changes of the anchovy and sardine. Smith and others in 1992 and Butler and others in 1993 used stage-specific matrix population models to assess the population growth of the northern anchovy and the Pacific sardine. In their study of both species, Smith and others investigated the changes in vital rates (instantaneous mortality rates [IMR], duration within stage, and age-specific daily fecundity [number of eggs produced per female]) required for a 30-percent change in population size. Thirty percent was used because it was within the range of population change of the Pacific sardine in the time period before its collapse. Butler and others, in their study, assembled the stage-specific vital rates of these two species from existing literature and examined the effect of extreme values of each vital rate on population change. Both studies assumed a fixed duration for all fish within a stage.

Until now, no attempt has been made to examine the effect of variability of the duration of developmental stages among individuals on population growth rates. However, in a study by Statistician Nancy Lo and Fishery Biologists Paul Smith and John Butler, two methods are used to assess the somatic growth rates of the northern anchovy and Pacific sardines. Method I assumes a fixed duration within stage, and method II assumes that the duration within stage is variable. Lo, Smith, and Butler investigated both methods and discuss their effects on population growth. They examined the effect of the percentage (rather than absolute) change of vital rates on the percentage change of population because using the percentage change makes it easier to compare vital rates that are measured by different units.

Based on the available vital rates within each stage, Lo's, Smith's, and Butler's analysis indicates that the two methods give different estimates of the population growth of both northern anchovy and Pacific sardine. If one assumes that duration within stage is fixed, both species are projected to be stationary whereas if one assumes duration within stage to be variable, both species are pro-

jected to be increasing. The effect of each vital rate (x) on the population growth rate (λ) is measured by its elasticity (e_x) as

$$e_x = \frac{\partial \lambda / \lambda}{\partial x / x}$$

where λ is the dominant eigenvalue of the population projection matrix. The matrix consists of stage-specific probability of surviving and staying in the same stage (Pi), the probability of surviving and growing into the next stage (Gi), and the daily fecundity rate (Fi).

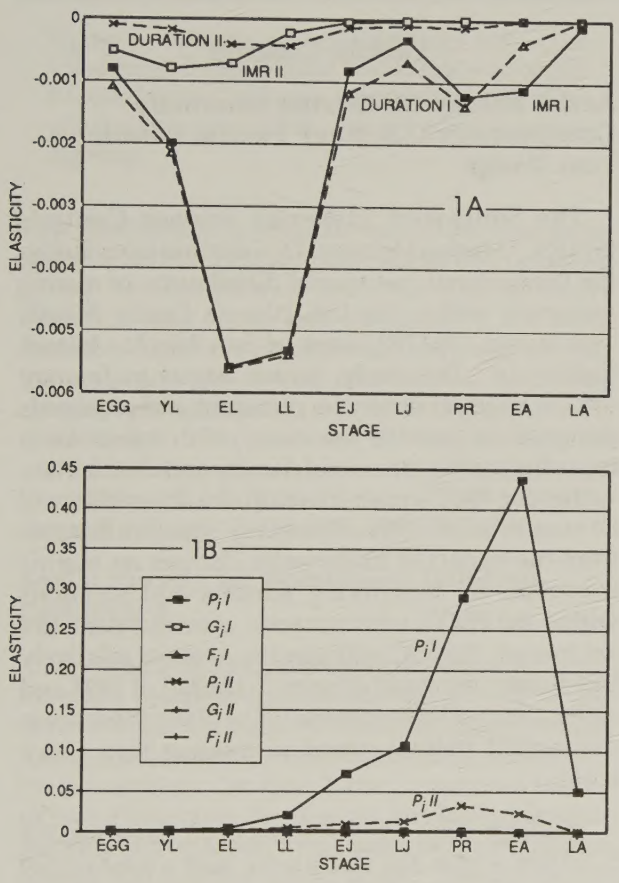

Figure 1. Elasticity of instantaneous mortality rate (IMR) and duration within each stage for northern anchovy (1A). Elasticity of the probability of surviving and staying in the same stage (P_i), the probability of surviving and growing into the next stage (G_i), and the daily fecundity rate (F_i) within each stage for northern anchovy (1B). I refers to method I and II refers to method II. YL=yolk-sac larvae, EL=early larvae (4-10 mm), LL=late larvae (10-35 mm), EJ=early juvenile (35-60 mm), LJ=late juvenile (60-85 mm), PR=pre-recruits (85-110 mm), EA=early adult (110-135 mm), and LA=late adult (135-160 mm).

The elasticity analyses indicated that under method I, the population growth of both species is sensitive equally to the percentage changes of mortality (IMR) and growth (duration). The most elastic stage is early larvae (4-10 mm) for anchovy (Fig. 1A) and late larvae (10-35 mm) for sardine (Fig. 2A). However, under method II, both species are sensitive more to the percentage change of IMR than to the duration, primarily due to the variable duration within stage. For anchovy, the most elastic stage for IMR is yolk-sac larvae, and for duration, it is late larvae (10-35 mm). For sardine, the most elastic stages for IMR are eggs and yolk-sac larvae, and for

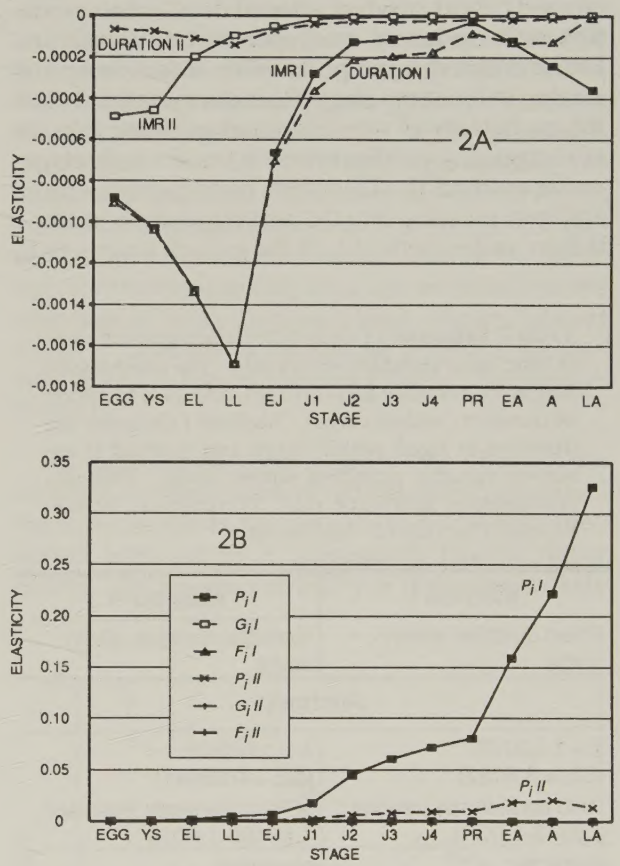

Figure 2. Elasticity of instantaneous mortality rate (IMR) and duration within each stage for Pacific sardine (2A). Elasticity of the probability of surviving and staying in the same stage (P_i), the probability of surviving and growing into the next stage (G_i), and the daily fecundity rate (F_i) within each stage for Pacific sardine (2B). I refers to method I and II refers to method II. YL=yolk-sac larvae, EL=early larvae (4-10 mm), LL=late larvae (10-35 mm), EJ=early juvenile (35-60 mm), J1=juvenile (60-85 mm), J2=juvenile (85-110 mm), J3=juvenile (110-135 mm), J4=juvenile (135-160 mm), PR=pre-recruits (160-185 mm), EA=early adult (185-210 mm), A=adult (210-235 mm), and LA=late adult (235-250 mm).

duration, it is late larvae. The population growth is least sensitive to the change of fecundity (Figs. 1B and 2B). Overall, the life stages with highest elasticity for anchovy are yolk-sac larvae through late larvae). The most elastic life stages for Pacific sardine are eggs to late larvae.

The two methods produce different λs: the λ value from method II was always higher than the λ value from method I. This is an indication that variation in individual growth enhances the population growth, primarily due to size-dependent mortality (Table 2). Rice and others, in 1993, found that high variation in larval growth leads to increased cohort survival after 60 days, when predation rates on larvae are dependent on larval size. Under method I, the probability of surviving and staying in the same stage (P_i) is always greater than the probability of surviving and growing into the next stage (G_i), yet the reverse is true for early stages under method II. Thus, fish have a greater probability of growing into the next stage under method II than under method I. If the growth among individuals varies, other things being equal, the fast-growing fish will contribute more to the increase of the population while the slow-growing fish will suffer higher mortality. However, it may take a long time to reach a stable population due to the low elasticity values. For marine fishes, method II is a more realistic model to use than method I since the environment is never constant and the growth of fish always varies. (N. Lo, [619] 546-7123; P. Smith, [619] 546-7169; and J. Butler, [619] 546-7149)

Table 2. Estimates of daily population growth rates (λ) and their standard errors (SE). The most elastic stages for anchovy and sardine under two methods of duration within stages. Method I assumes the duration is fixed within stage and method II assumes variable duration within stage. IMR=instantaneous mortality rate, YL=yolk-sac larvae, EL=early larvae, LL=late larvae.

Method I	Method II
Fixed duration within stage	Variable duration within stage
Anchovy	
λ = 1.000707 (SE = 0.0032) 95% confidence interval: 0.9943-1.0071	λ = 1.00246 (SE = 0.00041) 95% confidence interval: 1.00166-1.0033
elasticity: IMR EL (-0.0056)* duration EL (-0.0056)	elasticity: IMR YL (-0.000800) duration LL (-0.000426)
Sardine	
λ = 0.99986 (SE = 0.00119) 95% confidence interval: 0.9975-1.00216	λ = 1.00063 (SE = 0.000276) 95% confidence interval: 1.00008-1.001182
elasticity: IMR LL (-0.00170) duration LL (-0.00169)	elasticity: IMR EGG,YL (-0.00048) duration LL (-0.00014)

* For an increase of 1% of IMR per day (for example, from 0.5 to 0.505), the population will decrease by 0.0056% per day.

MARINE MAMMAL DIVISION

La Jolla, California

Aerial Survey for Marine Mammals Continues in U.S. Navy Pacific Missile Test Range

The Southwest Fisheries Science Center's (SWFSC) Marine Mammal Division has been studying the seasonal and spatial distribution of marine mammals within the U.S. Navy's Pacific Missile Test Range (PMTR), west of San Nicolas Island, California. The study, which began in January 1993, is an aerial survey for cetaceans and pinnipeds designed to provide the Navy with information regarding marine mammal density and distribution within the PMTR prior to a ship shock test that will be conducted in 1994. The Navy's goal is to minimize the impact of underwater charges on marine mammals by identifying seasons and locations within the PMTR where marine mammal densities are lowest. SWFSC will identify areas of relatively low marine mammal density in the fall of 1993 and at that time will recommend to the Navy those areas that would be best suited to conduct ship shock trials.

Through June 19, 1993, surveys have totaled 5,719 km within the study area, and a total of 249 on-effort sightings have been recorded both in and outside the study area (Fig. 1). Oceanographic data will be used in conjunction with the sighting data to better predict when and where areas of relatively low marine mammal density may occur. These oceanographic data are currently in the form of sea-surface temperature satellite imagery. Aerial expendable bathythermographs will be utilized on future surveys to collect additional data on the thermocline topography of the study area.

The Center's Marine Mammal Division has been asked by the Navy to provide personnel during the

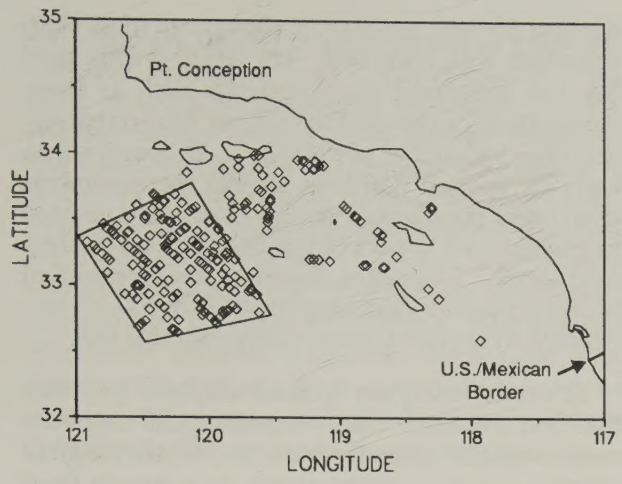

Figure 1. Marine mammal sightings within the U.S. Navy's Pacific Missile Test Range west of San Nicolas Island, California, January-June 1993. On-effort sightings total 249. Each ◊ = one mammal sighting.

ship shock trials to monitor operations and to ensure that no marine mammals, sea turtles, or endangered or threatened seabirds are within a 2-nautical-mile (nmi) area surrounding the shock trial site. Marine mammal observers will monitor the proposed shock trial area from a fixed-wing aircraft, two helicopters, and the Navy vessel being shock tested. The presence of marine mammals within a 2-nmi radius surrounding the shock trial operation will result in the immediate postponement of the trial. (J. Carretta, [619] 546-7181)

Aerial Survey for Bottlenose Dolphins Completed

On June 2–3, 1993, the Coastal Marine Mammal Program completed a two-aircraft survey of bottlenose dolphins, *Tursiops truncatus*, along the California coast from the U.S./Mexican border north to Pt. Conception. On June 2, three observers in each of two Partenavia fixed-wing airplanes surveyed the same survey area, flying just one hour (approximately 100 nautical miles) apart. The use of two aircraft will aid in determining whether separate surveys flown over a short time period yield similar data on the number of dolphins present in the survey area. On June 3, observers in one aircraft surveyed along the coast from Pt. Conception south to the U.S./Mexican border while observers in the second aircraft surveyed around the following islands: Anacapa, Santa Cruz, Santa Rosa, San Miguel, Santa Barbara, Santa Catalina, and San Clemente.

Survey conditions on June 2 were generally good with a majority of the effort conducted in a Beaufort 3 sea state (gentle breeze). The coastal waters were very murky, however, which made counting animals difficult. On this day, the leading aircraft (recorded as survey A) detected 8 sightings of bottlenose dolphins, with a total of 211 animals. School sizes for survey A ranged from 2 to 60 animals. One small gray whale was seen in the kelp beds off La Jolla during survey A. The trailing aircraft (recorded as survey B) detected 14 sightings of bottlenose dolphins, for a total of 110 animals. School sizes for survey B ranged from 1 to 38 animals.

Survey conditions on June 3 (surveys C and D) were fair, with most effort being conducted in Beaufort 3–4 conditions (gentle-moderate breezes). Water turbidity near the coast on survey C was high once again. A total of 11 sightings, totaling 118 bottlenose dolphins, were recorded on survey C. School sizes ranged from 2 to 34 animals. On survey D, flown around the Channel Islands, one sighting of 49 bottlenose dolphins was recorded on the west side of Santa Catalina Island. Figure 2 shows sighting locations of bottlenose dolphins for surveys A and B; Figure 3 shows locations for surveys C and D.

The sighting patterns indicate that although the replicate surveys encountered animals in almost all the same locations, the number of animals counted varied, with survey A consistently having higher counts. The extreme turbidity of the water is likely

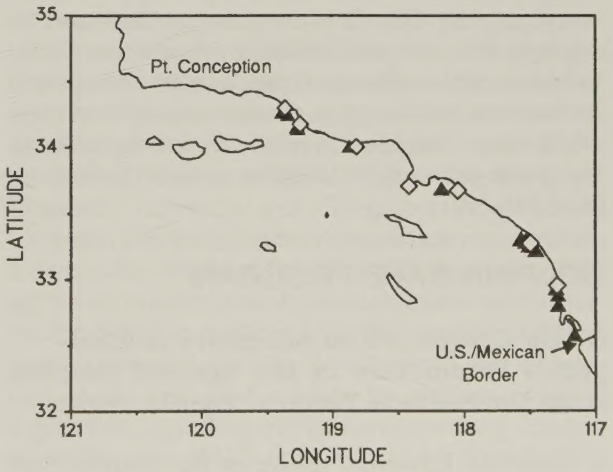

Figure 2. Aerial surveys of bottlenose dolphins along the California coast from the U.S./Mexican border north to Pt. Conception around the channel islands, June 2, 1993. ◊ = survey A and ▲ = survey B.

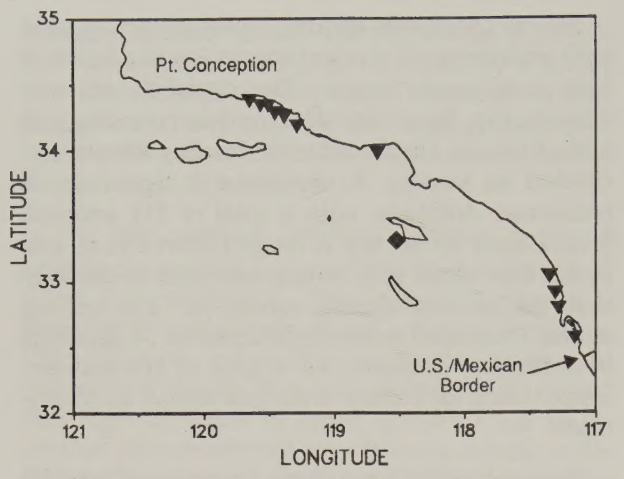

Figure 3. Aerial surveys of bottlenose dolphins along the California coast from the U.S./Mexican border north to Pt. Conception around the channel islands, June 3, 1993. ▼ =survey C and ◆ =survey D.

to have been the primary cause of this difference. Differences in circling patterns of the aircraft on surveys B and C may have also contributed to the discrepancy in counts. On survey A, several groups were found to be scattered over a considerable length of beach, and a wide area had to be covered to obtain a good count. In contrast, on surveys B and C, the aircraft circled around smaller areas to count the dolphins and as a result, the aircraft may have missed more-submerged subgroups between these sightings. On future surveys, it will be important to ensure that both aircraft follow similar circling guidelines and make sure their circles encompass all animals in the groups. During these surveys, this was difficult to evaluate due to the turbid water conditions. If possible, an attempt will be made in the future to conduct surveys on days when water turbidity is relatively low in order to maximize accuracy in dolphin counts (K. Forney, [619] 546-7171).

DOLPHIN-SAFE PROGRAM

Study Completed on Allometry of Energetics Parameters in the Spotted Dolphin from the Eastern Tropical Pacific Ocean

Elizabeth Edwards, leader of the Dolphin-Safe Research Program, has completed a study of allometric trends in morphological characteristics (relative growth or changes in proportion of body parts with size) of spotted dolphins from the eastern tropical Pacific Ocean. Her study is the first investigation, for any cetacean, of changes in these characteristics with body size. The study is important because measured characteristics such as those studied here can be used to estimate food consumption rates for natural populations. Although not an issue for spotted dolphins, similar measurements from other populations of cetaceans could be used to estimate the impact of the populations on their food supply. Estimating these impacts is important because cetacean food supplies are increasingly recognized to include commercially valuable fish.

Edwards' study on spotted dolphins provides the first evidence that morphological measurements must be taken from the entire size range of animals in a population rather than simply from adults. This is because morphological characteristics changed more rapidly with size in small (juvenile) animals than in large (adult) animals. This type of disproportionate change with size is an "allometric (nonlinear) trend."

Morphological measurements were taken from 35 spotted dolphins ranging in size from 77-210 cm total length. The dolphins were captured incidental to tuna purse-seine operations in the eastern tropical Pacific Ocean. The specimens included all sizes of males and females and included all reproductive stages for both sexes in reasonably equal proportion. Morphological measurements included surface areas of body and fins, metabolic surface area (beneath the blubber), and body proportions and energy content of body components (blubber, muscle, bones, and viscera).

Significant allometric (nonlinear) changes with size were observed in 23 of the 25 morphological characteristics (parameters) measured; no trends were isometric (linear). Most of the significant trends were expressed primarily during the first 2 or 3 years of life (5-30 kg wet weight). Thus, parameter estimates for small dolphins (less than about 30 kg wet weight) should be derived from measurements on animals near the specific size of interest. Estimates for larger animals, with the exception of several surface-area measurements, could be estimated reasonably well from any specimens greater than about 30 kg wet weight.

Although the energy fluxes and standing stock of energy represented by animals younger than 2–3 years are relatively small compared to the total population, constraints resulting from the energy characteristics of the smaller animals may exert significant control over population energy flux. For example, the swimming speed of a mixed-size school may be dictated by that of its youngest mem-

bers, who are unable to swim as fast as adults for extended periods of time. This implies that the rapid changes in energetics parameters of the younger animals should not be ignored. Dolphins less than about 3 years old comprise only about 10 percent of the population in these relatively long-lived and slowly reproducing mammals; dolphins age 3–12 comprise about 40 percent, and sexually mature adults, about 50 percent of the population. Because they are so few and because their biomass is so small, ignoring allometric effects when estimating energy fluxes for the younger animals, or ignoring the younger animals altogether, will have little direct effect on population energy budgets.

However, the indirect effects may be considerable. To the extent that activities of older animals are constrained by energy-related characteristics of young dolphins, indirect effects of size-related differences in estimated energy fluxes may be more important than the absolute fluxes themselves, through regulating behavior or ecological relationships. (See "Energetics of associated tunas and dolphins in the eastern tropical Pacific Ocean: A basis for the bond," Elizabeth F. Edwards, U.S. Fishery Bulletin 90(4):678-690.)

For example, muscle fraction of body mass in neonate dolphins (5 kg) is about 30 percent less than the muscle fraction in adults (70 kg). Thus, the power available for swimming (as a function of muscle mass) is 30 percent less than would be estimated based on measurements from adult animals. The estimated speeds that small dolphins, with their smaller muscle mass, can maintain will be slower than speeds estimated by simply applying the parameter values derived from adults to neonates.

This difference in estimated swimming speed may be important because dolphins are schooling mammals with apparently strong social ties and prolonged periods of parental care for nursing offspring. In order to remain within the same school, the average speed for all individuals will be constrained to the slower speeds that can be maintained by the smaller dolphins. Estimates from tagging studies of spotted dolphins in the ETP indicate that, in fact, the average cruising speed of dolphin schools is the optimum for the neonates rather than the adults, despite the fact that adults comprise the majority of individuals in the schools. Using parameters appropriate for adult dolphins in estimates for the smaller animals would produce unreasonably high estimates of sustainable power output (and, therefore, food consumption) by the smaller animals. School speeds, and therefore energy requirements to maintain these speeds, may thus be constrained by energetics characteristics of small animals that cannot be extrapolated simply from measurements on adults. The cost of transport is a large fraction of the total energy requirements of a swimming mammal. The active metabolism in swimming homeotherms (including dolphins, sea otters, and penguins) is generally two to three times that of resting metabolic rates. Maintaining reduced speeds should reduce energy costs and, therefore, forage requirements, for the school moving as a unit. This is particularly significant because forage requirements are the most commonly estimated energy flux used to estimate the impact of a cetacean population preying on a fisheries resource.

The practical significance of these results for a given population's consumption rate estimates will depend on values chosen for a number of parameters in addition to those presented here (for instance, ambient temperature, average swimming speed, size composition of the population). Such calculations are beyond the scope of the present study, but these results for spotted dolphins from the ETP show that allometric trends should be considered in such calculations. Similar effects probably occur in other cetacean populations and should be investigated. (E. Edwards, [619] 546-7099)

Effects of Dolphin Group Type, Percent Coverage, and Fleet Size on Estimates of Annual Dolphin Mortality Derived from 1987 U.S. Tuna-vessel Observer Data

The 1988 amendments to the U.S. Marine Mammal Protection Act (MMPA), coupled with changes during the 1980s in the composition of the international purse-seine fleet "fishing on dolphin" for yellowfin tuna in the eastern tropical Pacific (ETP), motivated Leader of the Dolphin-Safe Program Elizabeth Edwards and Computer Programmer Christina Perrin to conduct simulation experiments to assess the effects of fleet size and observer coverage level on estimates of cumulative annual mortality for dolphin stocks. The data quality differed greatly between stocks. Results from this simulation study provided a basis for subsequent U.S. legislation regarding criteria for comparing dolphin mortality rates of U.S. versus non-U.S. fleets fishing in the ETP, pursuant to regulations governing import of tuna from this area.

Since 1972, dolphins inadvertently killed by U.S.-registered tuna purse seiners fishing in the ETP have been monitored by scientific observers accom-

panying seiners on routine fishing trips. The kill data are monitored to determine whether annual quotas have been reached for dolphin mortality overall, and for several specific stocks of dolphins. If and when any quota is reached, fishing must cease on the affected stock for the remainder of the fishing year. Since 1989, the data have also been used to determine annual dolphin mortality rates for comparison with non-U.S. fisheries.

Prior to 1987, this kill monitoring was accomplished by sending observers on 30 to 50 percent of the trips made by U.S. purse seiners during a given year. Thus, mortality was estimated rather than measured directly. In the absence of any alternative, that is, higher rates of observer coverage, the accuracy and precision of these estimates were assumed to be adequate. This assumption was acceptable at the time because the U.S. fleet was large and generated a lot of data. About 100 vessels fished the ETP each year, each vessel making two to five trips of about 3 months duration each.

The situation changed dramatically in the 1980s when, for a variety of reasons, the U.S. fleet began to decrease at a rate of about 20 percent per year, from over 90 vessels in 1981 to about 10 vessels in 1992. This decrease in size of the U.S. fleet was offset by a reciprocal increase in the number of non-U.S. vessels fishing in the ETP. This increase has been dominated by Mexican vessels (fleet size exceeding 50 vessels by 1990) but also includes smaller fleets from several other nations. These smaller fleets range in size from 1 to about 20 vessels. In addition to these changes in composition of the international fleet, the 1988 amendments to the MMPA stipulated that yellowfin tuna caught in the ETP could be imported from non-U.S. countries only if mortality rates for those countries were comparable to U.S. kill rates.

These events created a strong incentive to evaluate the effects on mortality estimates of varying observer coverage levels and fleet sizes. Because the new regulations pertained to some individual stocks in addition to dolphin mortality overall, the previously uninvestigated effect of dolphin group type was also of interest.

The U.S. data set for 1987 provided a unique opportunity to investigate these effects. That year for the first time, observers accompanied fishermen on nearly 100 percent of the trips made by U.S.-registered purse seiners to the ETP. By subsampling the 1987 data set, various observer levels and fleet sizes could be simulated and their effects on dolphin mortality estimates studied. In the absence of any other available data, these data were taken by NMFS as being roughly representative of the international fleet. The simulation results guided subsequent legislation regarding mortality comparability criteria for non-U.S. fleets in the ETP.

Total annual mortality was estimated for three dolphin groups (all stocks combined): spotted dolphin, *Stenella attenuata*; whitebelly spinner dolphin, *Stenella longirostris longirostris*; and common dolphin, *Delphinus delphis*. These three groups represent the range of data types (good, intermediate, and poor in quality, respectively) in the 1987 data set and are generally representative of data types collected from the fishery every year which may be affected by variable fleet sizes and levels of observer coverage in future fishing years.

Accuracy (in terms of relative bias) and precision (in terms of coefficient of variation) of mortality estimates were influenced very strongly by data quality (dolphin group type) and moderately strongly by fleet size and level of observer coverage. Accuracy and precision were greatest for the dolphin group with the highest quality data (mortality per day was relatively similar across sets and relatively common throughout the year) and for larger fleets with higher levels of observer coverage. Because neither fleet size nor dolphin group type can be controlled by a sampling program, desired levels of accuracy and precision in estimates of dolphin mortality can be achieved only by manipulating the level of observer coverage. The unexpectedly strong effect of dolphin group type implies that to protect all groups equally, observer levels should be chosen to accommodate the dolphin group type exhibiting the poorest-quality data. (E. Edwards, [619] 546-7099; C. Perrin, [619] 546-7078)

Tuna Discards Studied from Log, School-fish, and Dolphin Sets by U.S. Tuna Purse Seiners in the Eastern Tropical Pacific Ocean, 1989-1992

Tuna purse seiners in the ETP set on three different types of tuna schools: schools of relatively small tuna (either pure schools of yellowfin tuna, *Thunnus albacares*, or mixed schools of yellowfin and skipjack tuna, *Katsuwonus pelamis*), schools of relatively small tuna (either pure yellowfin or mixed with skipjack) associated with logs or other floating objects, and schools of large yellowfin tuna associated with dolphins, in which the dolphins may be captured in addition to the tuna. Dolphin sets are preferred by the purse seiners because the fish caught are relatively easy to locate, abundant,

large, and more valuable per pound than the smaller school or log fish.

Recent (1988) amendments to the Marine Mammal Protection Act, pressures from conservationists, and decisions by U.S. canneries have led to a decrease in dolphin fishing and a corresponding increase in log and school fishing by U.S. vessels in the ETP. Dolphin sets are opposed by conservationists because dolphins may become tangled in the nets and suffocate. Recent efforts to eliminate dolphin sets altogether have led to questions regarding what effect the redirection of effort on dolphin sets to effort on school and log sets will have on the tuna resource and the ETP ecosystem as a whole. One aspect of this switch involves the bycatch associated with each type of set, where "bycatch" is defined as the catch (and assumed death) of other biota in addition to the targeted tuna. As bycatch is generally discarded, it represents a "waste" of the biota involved. In the case of discarded tuna and other economically important species, it also represents wasted commercial resources.

The present study focused on the extent of tuna bycatch from the U.S. tuna purse-seine fishery in the ETP, primarily with respect to set type modified by geographic area. The study described the general characteristics of the available data in terms of patterns in effort and resulting tuna bycatch, and it included development of a formula to estimate average tuna bycatch per set, given set type and geographic area; the formula was used to estimate the total U.S. bycatch during the study period. The formula was then applied to estimate total discard by the international fleet (of which the U.S. fleet was only a small part) during the study period and to estimate expected bycatch if the international effort had been redistributed from sets made primarily on dolphins to sets made primarily on school or log fish.

Although more detailed data reports would have been desirable, currently available data for the U.S. purse-seine fleet include only per-set estimates of total tons of tuna discarded. Data on size-classes and species composition of this discarded tonnage are not available, nor are data available on discards of species other than tuna. This study could not include data about bycatch from the considerable number of non-U.S. purse seiners fishing in the ETP, or from U.S. seiners fishing elsewhere than the ETP, because the data were not available to NMFS.

Observed tons of tuna bycatch per set (all tuna species combined) from U.S. tuna purse-seine vessels fishing in the ETP during 1989-1992 was two orders of magnitude higher for sets made on floating objects (log sets) than for sets made on dolphins (dolphin sets) and one order of magnitude higher than for sets made on pure schools of tuna (schoolfish sets). Estimated average bycatch was 7.0-15.0 tons per set on logs, 1.0-1.2 tons per set on schoolfish, and 0.06 tons per set on dolphins, depending on geographic area. Observed bycatch for the period was 9,819 tons from 1,004 log sets, 1,098 tons from 965 schoolfish sets, and 134 tons from 2,110 dolphin sets, generating a total observed bycatch of 11,051 tons in 4,079 sets. Bycatch was not recorded for all sets during the study period (50 percent of dolphin sets, 31 percent of log sets, and 27 percent of schoolfish sets did not include bycatch information). Extrapolating estimated average bycatch per set to the total effort by the U.S. fleet during the observation period produces total bycatch estimates of 15,558 tons due to log sets, 1,546 tons due to schoolfish sets, and 266 tons due to dolphin sets. Redistributing effort by U.S. seiners from setting primarily on dolphins to setting primarily on schoolfish or log sets during the observation period would have increased total bycatch by an estimated 357 percent (from 17,370 to 61,973 tons). Such redistribution of effort by U.S. boats is occurring in response to pressures to eliminate dolphin mortality by eliminating fishing on dolphins.

The U.S. fleet during the observation period was a small and decreasing fraction of the total international fleet. On average, only about one-eighth of the international fleet fishing during the study period (15 of the 120 vessels fishing the ETP) was U.S. registered. Assuming that non-U.S. vessels spent the same amount of time fishing as U.S. vessels, then tuna bycatch for the international fleet can be estimated very roughly by multiplying the estimated U.S. bycatch by a factor of eight. This produces an estimated total bycatch tuna of 138,960 tons. Had all effort been directed toward logfish, total bycatch of tuna might have been as high as 495,784 tons.

These estimates of bycatch extend through 4 calendar years, but actually include only about 36 months (3 years) of data. Dividing the estimates of total bycatch by 3 produces a rough annual estimate of 5,790 tons of bycatch from the U.S. fleet and 46,320 tons from the international fleet. In comparison, total catch of yellowfin and skipjack tuna by the U.S. fleet during the single year 1991 was 36,800 tons; total catch by the international fleet was 330,343 tons. Thus, estimated bycatch represented about 14 percent (5,790/[36,800+5,790]) of the tuna caught by the U.S. fleet and 12 percent

(46,320/[330,343+46,320]) of the tuna caught by the international fleet. Although this appears to represent a relatively small fraction of the total catch, its cumulative effect on the tuna populations could be substantial since this bycatch is composed primarily of pre-reproductive fish. (E. Edwards, [619] 546-7099)

POPULATION IDENTITY PROGRAM

Consumption of Prey Studied for Eastern Tropical Pacific Spotted Dolphins and Yellowfin Tuna

Fishery Biologist Kelly Peltier and Wildlife Biologist Susan Chivers of the Population Identity Program, in collaboration with Lisa Roberts of Humboldt State University, have been analyzing the results from two independent studies and comparing the prey species consumed by spotted dolphin, *Stenella attenuata*, and yellowfin tuna, *Thunnus albacares*, from the eastern tropical Pacific. Only one set, collected in 1985, is available for which both spotted dolphin and yellowfin tuna were sampled simultaneously. The remainder of the sample collected from yellowfin tuna were collected between 1970 and 1972, and the spotted dolphin stomach samples were collected by observers on tuna purse-seine vessels between 1989 and 1991. The cephalopod mandibles (beaks) and fish otoliths recovered from the stomachs of these two species were used to identify the fishes and cephalopods consumed. Beaks from 38 cephalopod taxa were found in the spotted dolphin stomachs (n=428) and 25 different taxa were found in the yellowfin tuna stomachs (n=760). The most frequently occurring cephalopod taxa represented in the stomachs of the spotted dolphin and the yellowfin tuna differed. For the spotted dolphin, the most frequently occurring cephalopods were squids of the family Ommastrephidae, whereas for the yellowfin tuna, they were the surface-dwelling argonauts, family Argonautidae. The fishes have been identified from only a subset of the spotted dolphin stomachs. The most frequently occurring fishes identified to date were members of the family Myctophidae. Stratification of the yellowfin tuna by area and the spotted dolphin data by management unit or stock indicate that the species composition of the prey changes seasonally and geographically.

Peltier and Chivers further stratified the data from the spotted dolphin sample to look for changes in stomach fullness with time-of-day as supporting evidence for the theory that spotted dolphins feed at night. There is a significant difference in stomach fullness between dawn and dusk; stomachs collected in the morning generally contain fresh prey items, and those collected in the late afternoon are empty of fresh prey remains. The most predominantly occurring squid found in the dolphin stomachs (Ommastrephidae) are primarily found in the deep scattering layer that comes to the surface at night. Peltier and Chivers also tested the hypothesis put forward in the published literature that the proportion of squid in the diet of pregnant female spotted dolphins is significantly greater than for lactating females. Based on their analyses, the proportion of beaks recovered from the stomachs of lactating or pregnant females is significantly different, but it is the lactating females that show a greater proportion of squid consumed. (S. Chivers, [619] 546-7093)

HONOLULU LABORATORY

Honolulu, Hawaii

FISHERIES OCEANOGRAPHY RESEARCH PROGRAM

Laboratory Participates in Workshops on Introduced Species

The Honolulu Laboratory recently participated in two workshops related to one of the threats to biodiversity—the introduction of nonindigenous species. Species introductions have increasingly created problems worldwide. In response to one of these problems, the introduction of the zebra mussel, *Dreissena polymorpha*, into the Laurentian Great Lakes, Congress enacted the Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990. The Act covers all introductions of aquatic species throughout the United States; NOAA and the U.S. Fish and Wildlife Service are jointly responsible for its implementation. Bruce Mundy, fishery biologist, recently represented the Honolulu Laboratory at workshops held to develop action plans needed to implement the Act.

The first workshop addressed nonindigenous estuarine and marine organisms and was held April 19-22 in Seattle, Washington. The workshop was convened by NOAA's Office of the Chief Scientist, Washington, D.C. Present were over 60 representatives from the NMFS, Environmental Protection Agency, U.S. Fish and Wildlife Service, U.S.

Coast Guard, U.S. State Department, U.S. Department of Agriculture, Commonwealth Scientific and Industrial Research Organization (Australia), Department of Fisheries and Oceans (Canada), Commission of the European Communities, International Council for Exploration of the Sea, universities, state aquatic resource agencies, and the shipping, aquarium, and aquaculture industries. The workshop's sessions, four formal presentations, were each followed by group discussion to develop a consensus about the problem and possible solutions to be implemented by the 1990 Act. General discussion topics included the extent of the problem, pathways of introductions, the theory of species invasions, ecological risk assessment, and criteria for regulating ecologically harmful activities. Specific topics included control of ballast water introductions, introductions through aquaculture, the aquarium industry's view of the problem, and existing government protocols addressing the problem in various states and nations. Mundy presented an example of local response to the problem in a paper titled "Policies, legislation, and other activities related to nonindigenous marine organisms in the state of Hawaii." Other presentations addressed education, biological control of alien species, and the use of marine sanctuaries to investigate introductions.

The second workshop addressed the severe problems caused by the brown tree snake, *Boiga irregularis*, on Pacific Islands and was held in Honolulu on May 20. The brown tree snake has attacked infants and destroyed bird populations on Guam following its introduction there; it poses a severe threat to Hawaii and other islands where it might be introduced. An amendment to the 1990 Act specifically calls for an action plan to control this snake. The brown tree snake workshop was convened by the U.S. Fish and Wildlife Service Pacific Islands Office, Honolulu, to develop the action plan. Present were 22 representatives from the U.S. Fish and Wildlife Service, U.S. Department of Agriculture, U.S. Air Force, U.S. Navy, Guam, Commonwealth of the Northern Marianas, Hawaii, universities, and private research laboratories. Mundy served as the NOAA representative to the workshop pending designation of a permanent representative for NOAA's Office of the Chief Scientist. Following presentations on the extent of the problem and possible remedies, workshop attendees were assigned responsibility to write sections of a draft brown tree snake control plan. This draft is to be completed by September 1993 and will be discussed at public meetings following its completion. (B. Mundy, [808] 943-1227)

PROTECTED SPECIES INVESTIGATION

Progress Made Toward Solving Green Turtle Fibropapillomatosis Disease

The results of tumor research conducted under contract by three specialists in wildlife diseases have recently been received by the Marine Turtle Research Program. This work is part of an ongoing collaborative effort to determine the etiology and possible containment measures needed to address the epidemic condition known as fibropapillomatosis. This disease is currently affecting green turtles in Hawaii, Florida, the Caribbean, and elsewhere worldwide. Prior to 1985, it was known at these locations but only as a relatively uncommon occurrence. During the last 5-8 years, the disease has substantially increased in both incidence and distribution. In December 1990, a major workshop was convened by the Honolulu Laboratory to address the problem and develop a coordinated research plan. In concordance with this research plan, various contracted studies have been under way since then.

The three contract reports recently received will be issued as Honolulu Laboratory administrative reports, an interim measure prior to eventual journal publication. The reports cover the topics of environmental pollutants, blood parasites, and immunodiagnostic techniques to measure exposure to the disease.

In the pollutant study, no organochlorines, polychlorinated biphenyls, organophosphates, or carbamates were detected in concentrations above detection limits in any of the numerous tissues examined from tumored turtles. In addition, most tissues were found to contain very low levels of 13 heavy metals investigated although few data exist on what constitutes "normal" levels in sea turtles.

In the cardiovascular parasite study, trematode spirorchid eggs were found in high numbers within all tumors surgically removed, digested, filtered, and counted. The eggs identified represented three genera, *Learedius*, *Hapalotrema*, and *Carettacola*. Evidence was obtained in support of the hypothesis that a protein on the spirorchid ova can cause the turtle host to react by forming fibrous tissue that proliferates into a fibropapilloma.

In the third study, considerable progress was reported in developing monoclonal antibodies, which are critical reagents necessary in a variety of diagnostic immunoassays needed to measure exposure to fibropapillomatosis in the wild. In addition, a tumor transmission study was conducted using captive-reared turtles exposed by various routes to possible etiologic agents. Two of nine turtles tested developed the disease, but further work is under way to differentiate between tumor cell transplantation and possible virus transmission. (G. Balazs, [808] 943-1240)

INSULAR RESOURCES INVESTIGATION

Northwestern Hawaiian Islands Lobster Fishery Closed in 1993

The Western Pacific Regional Fishery Management Council has decided that there will be no lobster fishery in the Northwestern Hawaiian Islands in 1993. The fishery is a limited-entry fishery with an annual harvest quota set at a level estimated to achieve a season catch-per-unit effort (CPUE) of 1.00 lobster per trap-haul. Based on the CPUE from the 1992 season (0.59 lobster/trap-haul) and population growth and mortality estimates from recent years, the Insular Resources Investigation of the Honolulu Laboratory has forecast that the resource probably will not recover to a level sufficient in 1993 to support a fishery with a season average CPUE of 1.00 lobster/trap-haul. (J. Polovina, [808] 943-1218)

Data Analysis Continues for Pearl Harbor Nehu Project

Data analysis continues for the 1986-88 nehu, *Encrasicholina purpurea*, project in Pearl Harbor, a tropical estuary on the island of Oahu, Hawaii. Collaborative work between Fishery Biologists Donald R. Kobayashi of the Honolulu Laboratory and David A. Somerton of the NMFS Seattle Laboratory has most recently involved an application of a spawner-recruit (SR) model to the 2 years of weekly spawning biomass and recruitment data.

Much of the initial justification for the Pearl Harbor nehu study was related to a proposed freshwater entrainment project that would trap stream flow water in the upper reaches of Pearl Harbor's West Loch for irrigation purposes. The NMFS study was an attempt to examine the possible effects that this habitat alteration would have on the resident nehu population. This necessitated a thorough understanding of nehu population dynamics and any possible linkages to Pearl Harbor hydrographic features. In a recently completed manuscript, Kobayashi and Somerton used the SR analysis to evaluate the importance of environmental effects on a particularly vulnerable stage of nehu life history: the recruitment success of larvae and juveniles. Essentially, the technique compares the abundance of spawning fish with subsequent (time-lagged) recruitment and determines whether or not another variable (for example, a time series of environmental data) can significantly account for the variability in some expected relationship between the numbers of spawners and recruits. Preliminary findings with a Ricker SR model suggest that there may be negative environmental effects from weekly mean water temperature and wind speed as well as the positive effect of freshwater stream discharge into the harbor on nehu recruitment success, expressed as a log-transformed survival index of recruits. The exact nature of these effects and their interrelationships is the subject of further examination. For example, all three of these variables may be related to hydrographic features such as water column stratification or mixing; the weekly CTD profile data may prove useful in understanding the fine-scale circulation patterns within Pearl Harbor.

Also completed for the nehu project is a summary report describing the full array of biological and environmental data, including commercial catch statistics. This report, completed by Fishery Technician Kevin C. Landgraf and Kobayashi, will be circulated as a NMFS/Southwest Fisheries Science Center, Honolulu Laboratory, Administrative Report. (D. Kobayashi, [808] 943-1242)

FISHERY MANAGEMENT AND PERFORMANCE INVESTIGATION

Hawaii Lobster and Longline Fishery Annual Reports Completed

Robert A. Dollar, fishery biologist, completed the annual reports of the Northwestern Hawaiian Islands (NWHI) lobster fishery and the Hawaii longline fishery. These reports are issued as Honolulu Laboratory administrative reports (H-93-09 for the lobster report and H-93-12 [in preparation] for the longline report) and are distributed to the Western Pacific Regional Fishery Management Council and to participants in the fishery; they are made available to the general public.

NWHI Lobster Fishery

The 1992 NWHI lobster fishery was the first under a combined limited entry-seasonal quota program. Substantial declines in the fishery in 1990 and 1991 led to concern that the fishery had been overexploited. (Insular Resources Investigation Chief Jeffrey Polovina and University of Hawaii Oceanographer Gary Mitchum hypothesize that the problem is related to changes in the recruitment levels to the fishery because of variations in the sea-level regime in the area.) As a result of the depressed catch rates, the Council instituted the limited entry and seasonal quota schemes to prevent overfishing. The fishery was closed for part of 1991 and for most of the first 6 months of 1992. The early season forecast for the 1992 season (beginning in July 1992) was 750,000 legal lobsters (spiny lobster, *Panulirus marginatus*, and slipper lobster, *Scyllarides squammosus*, combined), but in mid-season it was adjusted downward to 438,000 lobsters.

Lobster landings in 1992 more than doubled those in 1991 but remained depressed compared to earlier years. Catch-per-unit effort was only 0.36 spiny lobsters per trap haul (approximately half the performance of the mid-to-late 1980s) and 0.23 slipper lobsters per trap haul.

The total landings for 1992 were 424,000 lobsters, worth $2.1 million (Fig. 1). Twelve vessels participated in the fishery (although one sank before actually fishing), and there were 720,000 trap hauls, down from 1 million in 1989 and 1990.

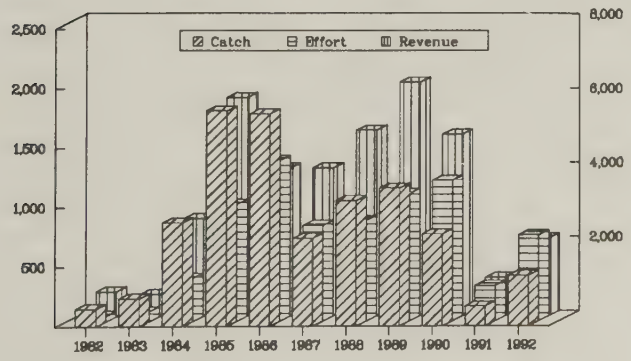

Figure 1. Northwestern Hawaiian Islands lobster fishery, 1982-92. Catch and effort (thousands of lobsters and thousands of trap-hauls) on left axis, and revenue in U.S. dollars (in thousands of dollars) on right axis. Data are based on Federal logbook reports.

Lobster prices were fairly strong in 1992, with an average of $14 per pound for frozen spiny lobster tails, but with higher prices up to $19 per pound. Slipper lobster tails were $8 per pound. During 1992, the market for Hawaii spiny lobster tails dramatically changed. The highest prices were recorded in January 1992, a period of limited world supply. But throughout the year, as world prices became depressed, Hawaii prices fell to as low as $12 per pound.

Hawaii Longline Fishery

The 1992 Hawaii longline fishery showed a continuing trend toward targeting swordfish (broadbill), *Xiphias gladius*. Overall, however, the rapid growth in the late 1980s and 1990-91 was halted by the late-1991 moratorium on new entry into the fishery. The moratorium is expected to be replaced by a formal limited entry program in April 1994, which may allow expanded fishing effort.

Total longline landings in 1992 were approximately 25.1 million pounds (using average weights applied to logbook number of fish), compared to 26.8 million pounds in 1991. Swordfish landings increased to 10.9 million pounds, up from 9.9 million in 1991. These data are based on the logbook records of federally permitted longline fishing vessels. Additional market information, as well as more detailed information on size composition, will be included in a forthcoming general report on Hawaii's pelagic fishery.

Swordfish was the largest component of the landings (71,000 fish), followed by mahimahi, *Coryphaena hippurus*, (53,900 fish), and bigeye tuna, *Thunnus obesus*, (42,750 fish). Blue shark, *Prionace glauca*, represented approximately 26 percent of the catch (61,500 fish), but few were landed. However, a market is developing for shark fins. Sharks which were finned but otherwise "released" may not have been recorded as "kept" in the logbooks. More on this topic will be covered in next year's annual report on the pelagic fishery as a whole. In Figure 2, 1992 and 1991 landings by species are compared.

Of 166 federally permitted longline vessels registered in Hawaii, 123 were active in 1992. Inactive vessels included vessels in the lobster and bottomfish fisheries, vessels which sank or had moved out of Hawaii, and 19 vessels that simply did not fish in 1992. In 1991, there were 140 active longline vessels in Hawaii.

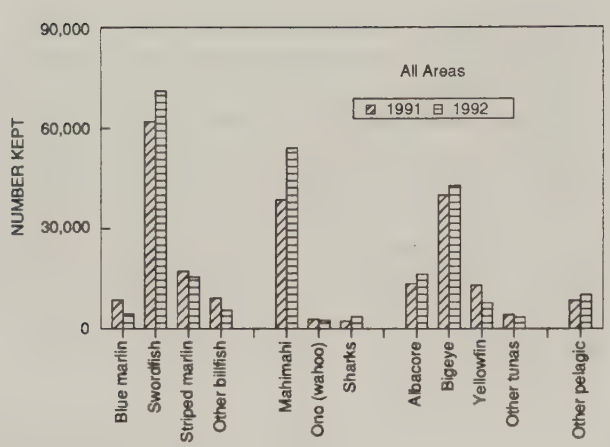

Figure 2. Hawaii longline fishery, 1991 and 1992. Species composition of landings (number of fish kept) is based on Federal logbook reports. Note: Longline figures have not been corrected for possible species misidentification. Major problems exist in the identification of blue and striped marlin (striped marlin are frequently misidentified as blue marlin). In the annual pelagic fishery report, shoreside sampling data are used to correct these figures. Sharks may also be mislogged as "kept" when they are killed and released while other sharks may not be logged as "kept" when finned.

There were 1,261 longline trips in 1992, compared to 1,665 trips in 1991. Approximately 22 percent of the trips specifically targeted swordfish while approximately 35 percent of the trips targeted tuna. The remainder (42 percent) represented mixed or unknown targeting. Fishing effort (number of hooks set) was predominately outside the U.S. Exclusive Economic Zone (EEZ) (52 percent). Remaining fishing effort within the 200-mile EEZ around the main Hawaiian Islands was 40 percent; within the Northwestern Hawaiian Islands (NWHI), it was 6 percent; and in U.S. possessions, such as Johnston Atoll, it was 2 percent.

Catch-per-unit effort (CPUE: number caught per 1,000 hooks set) for all areas was about the same in 1992 as in 1991. Swordfish CPUE was 6.36 per 1,000 hooks while bigeye tuna was 3.74 per 1,000 hooks.

Interactions with protected species are also recorded in the logbooks. The Hawaii fishery reported 180 interactions, of which 55.5 percent were with seabirds and 35.5 percent were with marine turtles. These interactions include those in which animals were released alive (either unharmed or injured), as well as those in which the animals were released dead. One dolphin and 71 seabirds were released dead in 1992. Over 80 percent of the interactions occurred outside the U.S. EEZ. (S. Pooley, [808] 943-1216)

PELAGIC RESOURCES INVESTIGATION

Presentation Made at Blue Marlin Workshop

Fishery Biologists Robert Skillman and Christofer Boggs and Industry Economist Samuel Pooley participated in a blue marlin workshop April 20-22, 1993, sponsored by the Western Pacific Regional Fishery Management Council (WPRFMC). These Honolulu Laboratory participants reviewed available fishery statistics and assessments which were presented at the workshop by Skillman. Case studies from other regions were presented by Robert Kearney of the Fishery Research Institute, Australia; Oscar Sosa-Nishizaki of Centro de Investigacion Cientifica y de Educacion Superior de Ensenada, Mexico; and Steve Berkeley of Oregon State University, formerly of the South Atlantic Fishery Management Council. The views of the charter boat industry, recreational fishermen, and the longline fishery were presented by members of the Hawaii fishery community, followed by a structured discussion to identify problems and recommend courses of action to the WPRFMC.

The Honolulu Laboratory overview provided information on catch and catch rates of blue marlin fisheries in the Pacific and on attempts at stock assessment. Pacific-wide catches reached an all-time high in 1990, the most recent year for which catch statistics are available. The increase is due to the expansion of Korean and Taiwanese longline fisheries since 1985. Stock assessments are out of date because of the unavailability of catch-per-unit effort (CPUE) data from foreign longline fisheries. One production model stock assessment, based on CPUE data through 1980, suggested that blue marlin were overexploited. More recent CPUE data through 1985 indicated little relationship between fishing effort and catch, preventing a meaningful production model assessment.

Hawaii fisheries account for less than 4 percent of the Pacific-wide harvest of blue marlin. Domestic longline landings decreased during the 1960s as foreign longline landings in the Hawaii area increased (Fig. 3). However, the first major increase

in Hawaii landings occurred in the late 1970s due to the expansion of domestic commercial troll fishing. A second major increase in landings occurred with the revitalization of the domestic longline fishery in the late 1980s, and Hawaii catches have been relatively stable since 1989 (Fig. 3). Despite these increases, commercial troll CPUE has not shown a downward trend in recent decades. A major decline in blue marlin CPUE in the Hawaii longline fishery from the 1950s through the early 1970s corresponded with a Pacific-wide trend unrelated to domestic fishery expansion. Since 1970, total Hawaii catch has increased in rough proportion to estimated equivalent Hawaii fishing effort (Fig. 4). Total equivalent Hawaii effort was estimated as catch divided by troll CPUE. Troll fishermen at the blue marlin workshop commented that catch rates have been maintained by improvements in fishing technology and they voiced their strong opinion that local blue marlin abundance has actually declined. (R. Skillman, [808] 943-1257; Chris Boggs, [808] 943-1222)

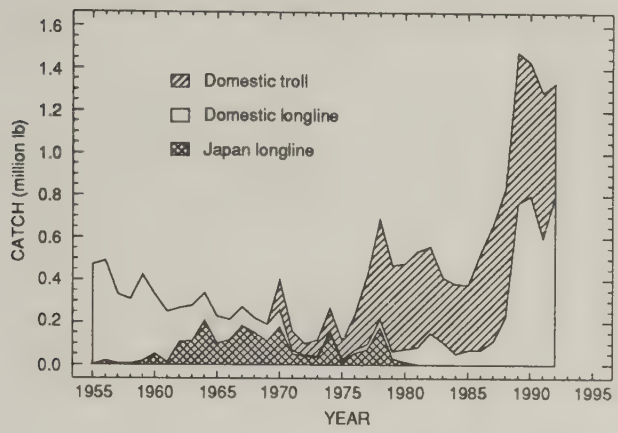

Figure 3. Hawaii commercial catch of blue marlin, 1955-92. Most "recreational" troll catch, including the charter fishing catch, is sold and thus should be reported as commercial catch. The completeness of this reporting is unknown. Japan longline catches are from two 5-square-degree areas adjacent to the main Hawaiian Islands.

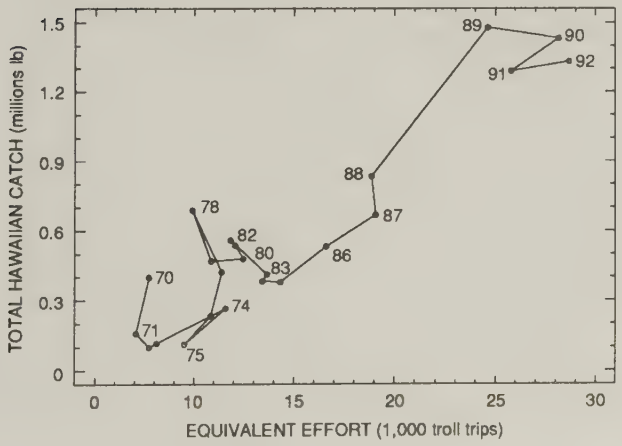

Figure 4. Hawaii catch of blue marlin in relation to estimated equivalent total effort (in troll trips) estimated from total catch divided by troll catch-per-unit effort, 1970-1992.

PELAGIC FISHERIES RESOURCES DIVISION

La Jolla, California

Third Meeting of the WPYRG Held in Pohnpei, Federated States of Micronesia

In 1990, the Western Pacific Yellowfin Tuna Research Group (WPYRG) was formed in response to growing concerns over the expanding fisheries and catch of yellowfin tuna in the western Pacific. The Group consists of scientists and fishery officers who are interested in collaborative research on western Pacific yellowfin tuna for management advice. They are principally from South Pacific island nations, distant-water fishing nations, the South Pacific Commission (SPC), and the Forum Fisheries Agency (FFA).

The strategic plan for the Group includes achieving three objectives by 1994 through collaborative research among participants. The objectives can be stated in three questions: (1) What is the safe level of yield and exploitation for the stock? (2) What is the level of interaction among the different fisheries? and (3) What factors contribute to local depletion?

The Group held its third meeting in Pohnpei, Federated States of Micronesia, from June 21 through 23, 1993, under the chairmanship of Gary Sakagawa of the Southwest Fisheries Science Center (SWFSC). Scientists and fishery officers from 16 Pacific countries as well as from the Food and Agriculture Organization, the FFA, and the SPC participated. SWFSC Statistician Al Coan and Fishery Biologist Pierre Kleiber also attended and contributed to the deliberations.

At the meeting, the participants reviewed the latest information on the yellowfin tuna fisheries of the western Pacific. The information indicated that the total catch continues to increase, 310,000 metric tons (t) for 1991, and a possible record of 349,000 t (estimated) for 1992. For 1993, preliminary information indicated poor fishing for many of the fleets during the first semester. If this continues for the remainder of the year, the Group concluded that the total catch for the year will be less than for 1992.

The Group also reviewed advances in development of a common data base, biological information, and investigations into stock abundance. The highlights of the reviews were that current catches are not excessive and the yellowfin tuna stock is capable of safely withstanding further fishing pressure. Catch-per-unit effort indices for monitoring trends in stock biomass were also determined to be unreliable and appropriately used only to monitor fishery performance.

The third meeting concluded with a list of tasks and research initiatives to be completed or begun during the coming year in preparation for the fourth meeting. 1994 will mark the end of the term of the strategic plan; consequently, the fourth meeting will be largely devoted to highlighting achievements in meeting the objectives of the plan and discussing the future of the Group. (G. Sakagawa, [619] 546-7177)

Report on Central and Western Pacific Yellowfin Catches Presented at WPYRG Meeting

Al Coan, mathematical statistician and task leader of the Multispecies Data Collection and Evaluation Program, presented a working paper at the WPYRG meeting held June 21-23, which describes U.S. yellowfin tuna catches from the central and western Pacific. The paper was coauthored with Doug Prescott, computer programmer.

Three types of U.S. fisheries that catch yellowfin tuna currently operate in the central and western Pacific: (1) the distant-water purse-seine fishery, (2) the Hawaii-based commercial fisheries, and (3) the artisanal fisheries.

The distant-water purse-seine fishery operates with purse seiners having 1,000 to 1,800 metric tons (t) carrying capacity in a large area of the southwestern Pacific. It targets yellowfin and skipjack tunas. The number of vessels participating in the fishery peaked in 1983 at 63, decreased to 32 in 1988, and increased to 44 in 1992. Yellowfin tuna landings peaked in 1987 at 66,400 t and, after a significant decrease the next year to 25,200 t, reached highs of 57,100 t in 1990, and 50,300 t in 1992 (Fig. 1). Statistics for the first half of 1993 show a decrease in both catch rate and average size of fish from statistics for the same period in 1992. Total yellowfin tuna landings in 1993 are therefore anticipated to be 25 to 30 percent of the 1992 landings, or approximately 35,000 t. The number of vessels fishing in 1993 is expected to be approximately 44, the same as in 1992.

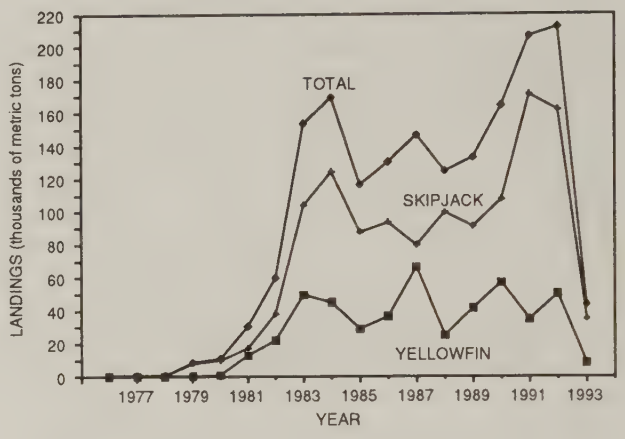

Figure 1. Distant-water landings (thousands of metric tons) of yellowfin and skipjack tunas from U.S. purse seiners fishing in the southwestern Pacific, 1976-1993.

Hawaii-based commercial fisheries and artisanal fisheries use primarily handline, troll, and longline gears and operate mainly within the Exclusive Economic Zones of Hawaii, Guam, American Samoa, and the Northern Marianas. They target a variety of tunas, tuna-like fishes, and billfishes.

The majority of the yellowfin tuna landings from U.S. artisanal and Hawaii-based commercial fisheries are from troll and handline gears operating in waters off Hawaii. Yellowfin tuna landings for Hawaii-based fisheries reached a high of 2,200 t in 1986. Since then, landings have decreased to 1,200 t in 1992 (Fig. 2). Yellowfin tuna landings for artisanal fisheries that operate off Guam, American Samoa, and the Northern Marianas are typically below 90 t a year.

Statistics to date for 1993 indicate that yellowfin tuna landings for the year will likely be approximately 1,400 t for Hawaii-based fisheries and about 70 t for the artisanal fisheries. (A. L. Coan, Jr., [619] 546-7079)

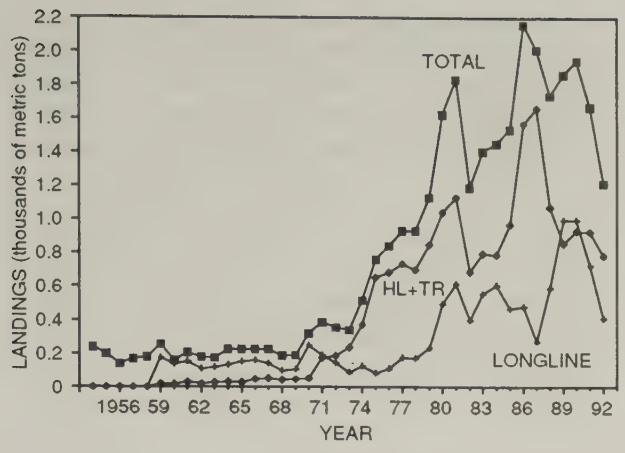

Figure 2. Landings (thousands of metric tons) of yellowfin tuna from U.S. artisanal and Hawaii-based commercial fisheries in the central and western Pacific, 1954-1992. HL+TR = handline and troll landings.

STOCK ASSESSMENT AND FISHERY IMPACT ANALYSIS PROGRAM

1993 Albacore Forecast Issued

The *1993 Albacore Forecast* was issued by the Pacific Fisheries Resources Division in early June 1993. The Forecast was based on fisheries and oceanographic data through mid-May. The following is an overview:

The overall outlook for the 1993 United States North Pacific albacore fishery is for moderate-to-good production, with potential landings exceeding the past several years. Residual warm water along the U.S. west coast and related oceanographic conditions make it probable that albacore availability will be highest in waters north of San Francisco; however, availability from south of San Francisco to southern California should be greater than experienced last year. Albacore are expected to arrive in large numbers near the coast in mid-July, with earliest arrivals in the south and later arrivals further north. Relatively strong nearshore upwelling and associated frontal structures are evident from southern California to Cape Blanco. Continued northerly winds in June and July will help maintain nearshore upwelling. Sportfishing for albacore should be relatively good along the coast wherever the fish are held by local fronts. Off southern California, frontal development should produce generally favorable conditions outside the Southern California Bight. Due to warmer than normal waters off Baja California, extending into the Bight, there is a greater-than-average probability, but not as great as last year, for yellowfin and skipjack tunas and other warm-water fish to be available in the Bight and along northern Baja California within reach of San Diego-based boats. Warm-water exotics will not likely extend north of Pt. Conception. (N. Bartoo, [619] 546-7073)

Shark Abundance Cruise Conducted

The Pacific Fisheries Resources Division (PFRD) and the California Department of Fish and Game (CDF&G) conducted an experiment in May to develop and evaluate a catch-per-unit effort index for pelagic sharks in the waters off southern California. Commercial landings for shortfin mako, *Isurus oxyrinchus*; common thresher, *Alopias vulpinus*, and blue sharks, *Prionace glauca*, have decreased substantially from highs in the mid-to-late 1980s. This, along with lack of information on age structure and other biological parameters, prompted the initiation of the experiment.

There is no consistent time series of catch-and-effort data that can be used to determine relative abundance of sharks off southern California. Changing management goals and an increasing number of regulations governing the shark fisheries of California have resulted in wide swings in catches, the distribution of fishing effort, and gear deployment. An experimental longline fishery for shortfin mako and blue sharks operated off southern California from 1988 to 1991. This longline fishery was regulated and conducted under standard procedures until suspended in 1991. Catch-and-effort data collected for this fishery appear to be the best time series available for monitoring mako shark abundance. However, the suspension of the fishery has left a data gap for recent years. The PFRD experiment was to determine if the gap can be bridged.

The experiment was built around standard longline procedures used by the pre-1991 fishery. The objective was to use commercially available longline gear to sample shark abundance in the waters off southern California. The NOAA ship *David Starr Jordan* was used as the fishing platform. Division staff members participating in the cruise included Computer Programmer Donna DaRodda; Fishery Biologists Dave Holts, Pierre Kleiber, and Darlene Ramon; and Biological Technicians John Childers, Randy Rasmussen, and Gary Rensink.

CDF&G biologists were Meladie Palmer-Zeahlen, Leanne Laughlan, and Don Armstrong.

Length of the longline was limited to 2 miles per set, with 100 to 200 hooks each, in the area formerly used by the longline fishery. Fishing for sharks was conducted during the day and sets at night targeted swordfish and sharks. Each set was fished for 3 hours. Underwater observations indicated the gear was fishing at depths between 70 and 90 feet.

Fishing effort totaled 1,974 hooks in 16 fishing sets. In 12 day sets, 1,508 hooks yielded 170 blue, 20 common thresher, 2 shortfin mako sharks, and 8 pelagic rays. An additional 466 hooks in 4 night sets yielded 76 blue sharks but no swordfish. The catch rate of 0.13 mako sharks was consistent with May rates for the pre-1991 fishing season. The catch rate of 1.33 thresher sharks per 100 hooks was unexpected and may indicate some resurgence in local abundance of this species.

All healthy sharks when caught were tagged and released alive. In all, 5 common thresher, 1 shortfin mako, and 147 blue sharks were tagged and released.

Heart and blood samples were collected from 38 additional sharks by Chin Lai of Scripps Institution of Oceanography. During these dissections, it was determined that several of the sharks (20 percent) had died from bleeding caused when the fishing hook was swallowed and subsequently pulled forward, penetrating the heart muscle proper.

A repeat of the experiment is being planned for September 1993 aboard the CDF&G research vessel *Mako*. (D. Holts, [619] 546-7186)

Albacore Drift Gillnet Interaction Project Continues

During May, NMFS Biological Technicians were trained and equipped for the North Pacific albacore troll fishery. Biological Technicians Eric Forney, Chris Fanning, and John Childers departed from Honolulu, Hawaii, aboard U.S. albacore troll vessels during the first week of June, and Gary Rensink departed from Newport, Oregon, during the third week of June. This is the fourth year for these observations, which are intended to quantify the interaction between U.S. albacore troll vessels and the high-seas drift gillnets and to collect biological data on albacore. The objective of the observations is to observe the daily catch of albacore for evidence of injuries caused by encounters with high-seas drift gillnets and to collect size-of-catch and other biological data. This is the first season after the 1992 United Nations moratorium on high-seas drift gillnet fishing in the North Pacific, so fresh gillnet marks on albacore are anticipated to be nil and far below the high of 12 percent observed in 1990.

Preliminary reports from the observers indicate good-to-moderate fishing within the North Pacific transition zone. Incidence of albacore with gillnet mark injuries is negligible in the offshore areas. (D. Holts, [619] 546-7186)

TIBURON LABORATORY

Tiburon, California

Biogeographic Model Applied to Whale Populations

In 1990, Alec MacCall, Director of the Tiburon Laboratory, published the book "Dynamic Geography of Marine Fish Populations," in which he described a theory of habitat selection as it relates to fish production and distribution. This year, the International Whaling Commission (IWC) invited MacCall to explore application of his theory to whale populations. In response, MacCall coauthored a paper with Kenichi Tatsukawa of the University of Tokyo's Ocean Research Institute. In April 1993, they presented the paper at the IWC Scientific Committee meeting in Kyoto, Japan.

The IWC's Scientific Committee has developed a sophisticated management strategy that has been tested extensively by computer simulation experiments. An important quantity in this strategy is the rate of harvesting at maximum sustainable yield (MSY). Many members of the Scientific Committee believe that the typical whale production curve is "convex," so that the per capita population growth rate (or equivalently, the sustainable harvest rate) initially does not decline quickly with increasing abundance but then falls suddenly as abundance approaches carrying capacity. For example, at an abundance of one-half of the carrying capacity, the per capita growth rate is assumed to be higher than one-half the growth rate at very low abundance. Much of the evidence for "convexity" is derived from observations of mammal reproductive rates at a single location, and it is commonly assumed that the overall population behaves similarly.

MacCall and Tatsukawa show that habitat selection can result in distortion of the production curve, so that "convexity" may hold at every location in the range of the population, and yet, the overall population per capita production rate curve can be "concave," exhibiting the opposite curvature. This distortion is due to range expansion and contraction coincident with changes in abundance. Averaged over the population, individuals tend to occupy better habitat when abundance is low and poorer habitat when abundance is high. If the population production rate curve is not "convex," MSY rate may not be as high as previously thought.

Little is known about habitat selection in actual whale populations, although in some cases, there is evidence that ranges have contracted under historical exploitation. The extent of habitat selection, and hence the effect on production curves, is unknown. MacCall and Tatsukawa's result does not require that the assumption of "convexity" be discarded. However, it does suggest that some of the evidence for "convexity" may not be as strong as was thought. MacCall and Tatsukawa conclude that it would be prudent to monitor the course of recovery of actual whale populations to look for direct evidence of "convexity" in the production rate curve. (A. MacCall, [415] 435-3149)

GROUNDFISH COMMUNITIES INVESTIGATION

Transformation of Mendocino Nearshore Habitat Continues

Changes in the nearshore habitat along the Mendocino coast since 1981 have been documented by Ted Hobson, Tony Chess, and Dan Howard of the Groundfish Communities Investigation. Areas forested by bull kelp, *Nereocystis luetkeana*, have experienced a transformation since the fishery for red sea urchins, *Strongylocentrotus franciscanus*, began there in 1984, and the changes involved have been reported in Southwest Fisheries Science Center's (SWFSC) bimonthly report since 1988. The first major change (described in the report for November/December 1988) involved the expansion of bull kelp with the decline of the herbivorous urchins during the early years of the fishery. This was followed by the development of an algal understory composed mainly of *Pterygophora californica* (described in the May/June 1990 report) that progressively supplanted the bull kelp in many areas. Then, last year it was noted (in the May/June 1992 report) that purple sea urchins, *Strongylocentrotus purpuratus*, were moving out from their normal locations close to shore into the deeper areas formerly occupied by red urchins and were grazing heavily on the understory. The purple urchins moved across the bottom, leaving areas in their wake completely denuded of understory. If the understory had precluded the bull kelp, as suggested in last year's report, one might predict that the bull kelp would, with this year's recruitment, become reestablished in these areas. So far, however, this has not happened.

Normally, *Nereocystis* sporophytes appear on the sea bed early in May and then rapidly develop as a dense growth of closely spaced plants that reach the water's surface by mid-June. But as of early June this year, there was virtually no bull kelp at the Mendocino study site. Although it had appeared that the earlier reduction in area forested by bull kelp related to problems with the understory, there must be some other reason for the virtual absence of bull kelp at the study site so far this year. One possibility is that factors related to elevated sea temperatures inhibit growth in bull kelp during the early sporophyte stage. This is suggested by the fact that during May of this year, the time that sporophytes normally begin their development, sea temperatures at the Mendocino site were far above those previously recorded (Fig. 1). (E. Hobson, J. Chess, D. Howard, [415] 435-3149)

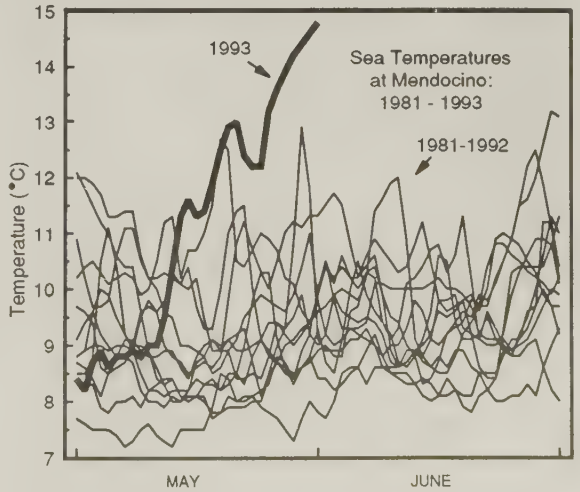

Figure 1. Sea temperatures at a depth of 10 m as recorded by a thermograph at the Mendocino study site, 1981-1993.

GROUNDFISH PHYSIOLOGICAL ECOLOGY INVESTIGATION

Yellowtail Rockfish Egg Quality Studied

Seven consecutive years of research of reproductive output, measured in age and size-specific fecundity, indicated that yellowtail rockfish reproductive output significantly varied among years and between locations. Such quantitative differences led to the question of whether reproductive output also varied qualitatively. Since rockfish are viviparous, qualitative properties can be thought of as those traits that relate to the egg, embryonic, or larval potential to produce viable offspring. In a recent study of 108 female yellowtail rockfish, collected by hook-and-line from 1986 to 1991, researchers examined egg quality variation between individual fish and compared quality variation to maternal factors.

The sample of adults included fish that ranged in age from 6 to 33 years, in somatic weight from 673 to 2,083 g, and in standard length from 29 to 46 cm. Fish were comprehensively examined and assessed for physiological condition and nutritional state. Additionally, blood sera were analyzed for nutrients. Qualitative traits of vitellogenic eggs, embryos, and larvae were determined by measurements of egg diameters, egg dry weights, caloric contents, total lipids, and total proteins.

Initially, factor analysis of the maternal and egg variables was used to reduce the number of variables and to identify related variables. The factor with the highest eigenvalue was characterized as the "egg quality" factor and was comprised of those associated variables that reflected ovary size (gonosomatic index, ovary weight), gonad maturity (gonadal maturity stages, oocyte-based ovary maturation stage), blood and body nutrients (globulins, proteins, albumins, liver lipids), and the egg quality variables of egg diameter, egg weight, and calories per egg. From this variable assemblage, one-on-one comparisons were made between maternal variables and egg quality traits. Resultant correlation coefficients ranged from 0.74 to 0.99, and analyses showed interesting patterns. Egg size measures of weight and diameter directly correlated with the amount of energetic calories per egg, the stage of development, and inversely with blood globulins and proteins. Both measures of the caloric energy levels, namely calories per gram and total calories per egg, were related to egg size, developmental stage, and depressed levels of blood proteins and liver lipids. Egg lipid content was also directly related to the amount of available egg energy (Fig. 2), further demonstrating the direct link between lipids and egg energy content. When the amount of energy per individual egg was analyzed by developmental stage (Fig. 3), it became apparent that energy levels increased steadily throughout vitellogenesis while yolk was being accumulated. Subsequent to fertilization, however, energy levels declined until just prior to larval release.

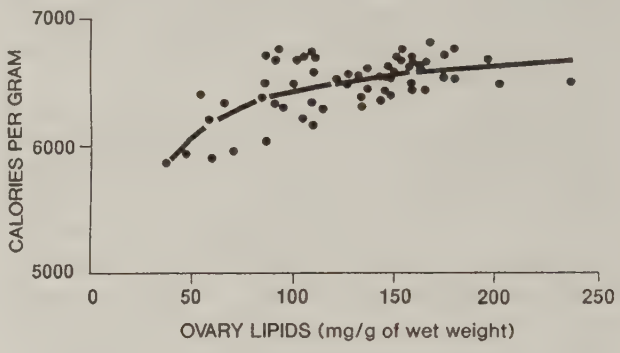

Figure 2. Total calories per gram (ash-free dry weight) of yellowtail rockfish eggs, embryos, and larvae and their total lipid contents in mg/g (wet weight).

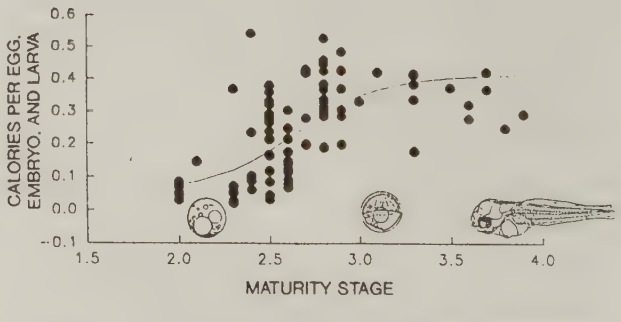

Figure 3. Total calories per individual egg, embryo, or larva, by maturity stage of yellowtail rockfish. Stage 2.0-2.9 represent vitellogenic eggs; stage 3.0-3.9 represent early embryo through hatched larvae.

The importance of lipids and lipid dynamics within the host female and the individual eggs, embryos, and larvae was indicated. Bioenergetic processes appeared directly related to these lipids. Further, if the goal is to assess and evaluate egg quality in viviparous rockfishes, one needs to sample eggs just prior to ovulation and fertilization, or sample larvae just prior to parturition. (M. Eldridge, [415] 435-3140)

Research Continues on Energetic-to-structural Lipid Ratios in Yellowtail Rockfish, as a Measure of Energetic Status

Energetic-to-structural lipid ratios have previously been used as a measure of energetic status or physiological condition in fish and other animals. Energetic lipids, mainly triacylglycerols, are used primarily as a source of fuel. Structural lipids are phospholipids and cholesterol, which contribute to cell membranes and the proliferation of tissues. Lipid classes were separated monthly in adult yellowtail rockfish ovaries over the 1990-91 reproductive cycle to determine temporal dynamics for the ratio of energetic-to-structural lipid classes (E/S). The E/S ratio analyses are a part of the Groundfish Physiological Ecology Investigation's (GPEI) comprehensive 7-year study on the yellowtail rockfish's physiological condition and nutritional state and their relationship to reproductive success.

Researchers have found an indication that yellowtail rockfish lipids are the most important reserve utilized in female-specific reproductive development, comprising approximately 75 percent of the energetic stores depleted from females for reproduction. An understanding of the dynamics in ovarian lipid ratios over the reproductive cycle will enable GPEI scientists to determine the optimum sampling time to easily compare interannual variability in lipid ratios as measures of energetic status. In Figure 4, an increase in E/S ratio from late summer to November is shown, then a decline through March. During the latter period, structural lipids increase as tissues are formed and energetic lipids are metabolized in the process as indicated by a decline in the E/S ratio. By determining the slope of the E/S decline and back calculating, the researchers can get an estimate of the E/S in pre-extruded larvae just prior to parturition. Assuming these fish are similar or representative of first-extruded larvae, they can estimate the energetic state and predict the potential of larvae to survive through the critical period, that is, before the first feeding begins. (E. Norton, [415] 435-3149)

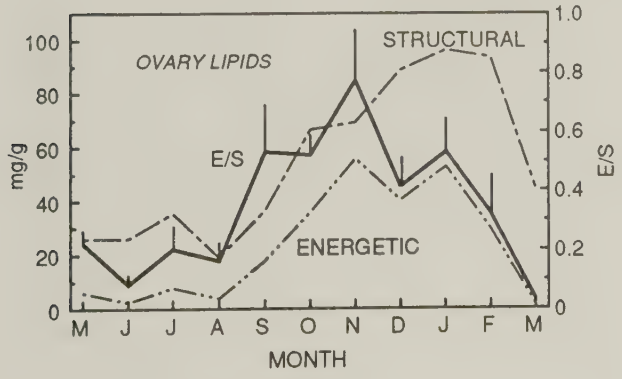

Figure 4. Monthly changes in mean energetic and structural lipids and their ratios in female yellowtail rockfish ovaries during one reproductive cycle. E/S = energetic-to-structural lipid class ratios.

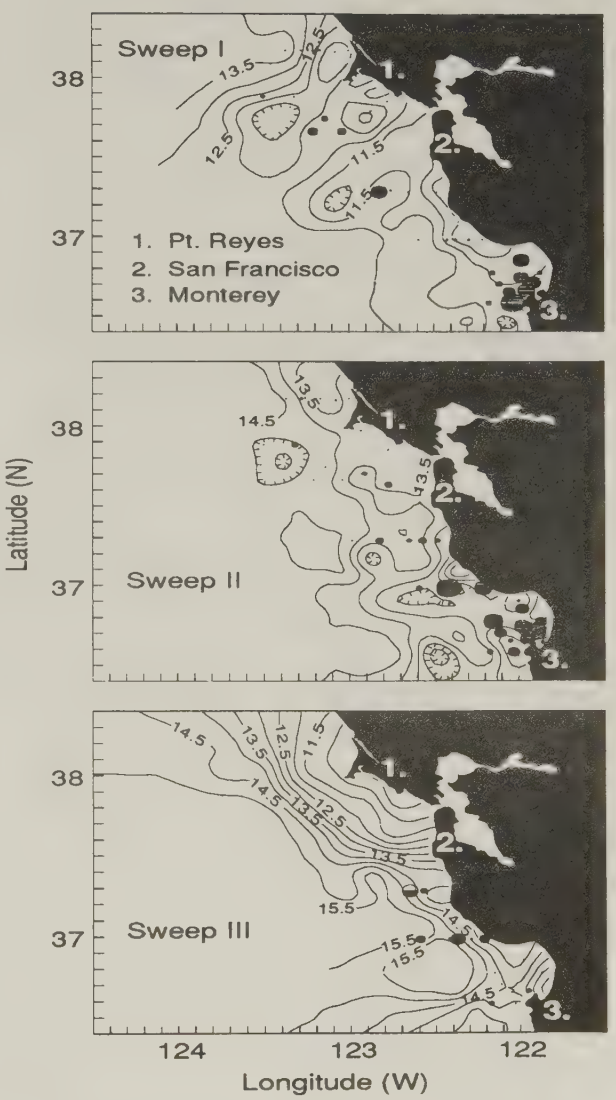

Figure 5. Temperature contours at 10 meters from conductivity-temperature-depth casts and at the locations of trawl stations (May 13 to June 13, 1993). The size of the round symbol is proportional to the catch of total rockfishes. Range of catch = 1–392 rockfish. Contours with hatch marks represent cooler waters; contours without hatch marks represent warmer waters (referenced on page 24).

GROUNDFISH ANALYSIS INVESTIGATION

Tiburon Biologists Complete 1993 Juvenile Rockfish Survey

Biologists from the Groundfish Analysis Investigation at the Tiburon Laboratory recently returned from a month-long survey aboard the NOAA vessel *David Starr Jordan*. The scientists recorded the distribution and abundance of juvenile rockfishes captured in a Cobb midwater trawl as part of a decade-long program to estimate rockfish reproductive success. The survey sampled 36 fixed stations between Cypress Pt. (36°30′ N) and Tomales Point (36°20′ N) and out to a distance of approximately 80 kilometers. Most stations were visited three times during the period between May 13 and June 13.

Oceanographic data were recorded to characterize the hydrography in which the fish were collected. These data included ocean currents, which were measured with an Acoustic Doppler Current Profiler. Sea-surface temperature and salinity were taken with a continuously recording thermosalinograph. Conductivity-temperature-depth casts were conducted at fixed stations which bracketed the trawl stations.

The survey team encountered a wide range of weather conditions, from calm winds and flat seas to 38-kn winds with rough seas. Ocean water temperatures were also variable with the most extreme situation encountered near Pt. Reyes, where the temperatures dropped from 16.1 to 9.0 °C over a distance of only 60 kilometers. These measurements were taken when the ship penetrated the well-known upwelling filament off Pt. Reyes. Surface temperatures tended to become warmer throughout the course of the cruise (Fig. 5, pg. 23).

A preliminary summary of the number of captured rockfish ranks 1993 in the top third of the 11-year time series. Sweep II, conducted from May 21 to May 27, yielded more fish than the other two sweeps (Table 1). The species composition of this year's catch was distinguished by the high proportion (22 percent of all rockfishes) of brown rockfish, *Sebastes auriculatus*, and the relatively low percent-

Table 1. Rockfish captured during the May/June 1993 juvenile rockfish survey.

Species	Sweep I	Sweep II	Sweep III	Total
shortbelly, *Sebastes jordani*	811	893	518	2222
chilipepper, *Sebastes goodei*	724	490	106	1320
brown, *Sebastes auriculatus*	116	629	480	1225
stripetail, *Sebastes saxicola*	136	178	0	314
copper complex, *Sebastes* sp. *caurinus* complex	9	34	39	82
widow, *Sebastes entomelas*	17	47	13	77
yellowtail, *Sebastes flavidus*	11	21	5	37
blue, *Sebastes mystinus*	10	11	11	32
Sebastes sp. (unidentified)	14	17	0	31
bocaccio, *Sebastes paucispinis*	16	8	2	26
squarespot, *Sebastes hopkinsi*	10	13	2	25
canary, *Sebastes pinniger*	7	5	2	14
darkblotched, *Sebastes crameri*	7	2	0	9
black, *Sebastes melanops*	2	2	2	6
olive, *Sebastes serranoides*	1	4	1	6
cowcod, *Sebastes levis*	2	2	1	5
bank, *Sebastes rufus*	0	5	0	5
halfbanded, *Sebastes semicinctus*	1	3	1	5
grass, *Sebastes rastrelliger*	0	1	1	2
pygmy, *Sebastes wilsoni*	2	0	0	2
Total	1896	2365	1184	5445

age (42 percent) of shortbelly rockfish, *Sebastes jordani*. As adults, *S. auriculatus* inhabit nearshore areas and remain near the bottom while adult *S. jordani* is a midwater species. The chilipepper rockfish, *Sebastes goodei*, also had a good recruitment year, with over 1,300 fish representing 24 percent of the rockfish catch. Chilipepper typically accounts for less than 10 percent of the catch and this has been the first year since 1988 when more than 1,000 of this commercially important species have been captured.

The spatial distribution of juvenile rockfishes changed during the three sweeps. On Sweep I, most of the rockfish were found in the Monterey Bay area. On Sweep II, higher numbers were observed in the more northerly region near Davenport. On Sweep III, all numbers were greatly reduced and the fish were distributed over a much wider area with very low catches in Monterey Bay (Fig. 5). As is typical, relatively few fish were captured this year in the Gulf of the Farallones or in the vicinity of Pt. Reyes.

Samples collected on this cruise represent a valuable addition to the 11-year time series being maintained at the laboratory. Tiburon researchers expect this data set to provide a tool useful in assessing the health of this recreationally and commercially important family of fishes. (D. Roberts, [415] 435-3149)

INFORMATION TECHNOLOGY SERVICES

Control Data Awarded NMFS IT-95 Contract

The Information Technology 1995 (IT-95) project was initiated in 1985 to service NMFS computing needs into the 1990s. It was NMFS' systematic approach to install a family of compatible computing resources at Headquarters, the five Regional Science Centers (Sand Point-Seattle, Washington; Montlake-Seattle, Washington; Miami, Florida; Woods Hole, Massachusetts; and La Jolla, California) and the three remote sites (Honolulu, Hawaii; Monterey, California; and Auke Bay, Alaska).

With the assistance of the technical users at each regional site, the National Data Management Committee developed, reviewed, and edited the specifications in the Request for Proposal and the benchmark package. After eight years of cycling through the review/rewrite/approval process, the efforts were rewarded on May 11, 1993, by the award of the $13 million contract to Control Data Systems (CDS) Inc. CDS, the integration arm of Control Data Corporation (CDC), will provide NMFS with the IT-95 resources: hardware, software, maintenance, training, documentation, and support services for NMFS.

CDS will provide Reduced Instruction Set Computer (RISC)-based host computers running the UNIX operating system. At NMFS' request, the proposed 32-bit IT-95 RISC servers and workstations will be upgraded to 64-bit hardware and software technology. This substitution, which will increase the cost of the systems and cause a short delay for system deliveries, is justified. Indications are that CDS will not make further enhancements to their 32-bit systems. If the latest technology is not purchased now, NMFS faces upgrading to the 64-bit system within two years. The 64-bit technology will support the users' new requirements due to new scientific modeling techniques and new software technology, which were not available when the specifications were first drafted.

With the contract awarded, the IT-95 project is shifting from the acquisition to execution phase. The immediate national focus is on-site preparation, staff training, software conversion, and development of data standards. To formulate the system delivery and user training plans, Hugh Johnson, NMFS IT-95 project manager, and Rob Smith, CDS IT-95 program manager, are holding meetings each Wednesday in the NMFS Headquarters office.

Johnson has distributed a first-draft IT-95 execution plan to the Regional Data Base Administrators. After their review and comments, the recommended plan will be given to the Assistant Administrator for Fisheries and the Regional Science Directors for approval. The plan, which proposes installation and implementation with minimal support, is based on IT-95 money-in-hand and on the known targeted IT-95 money in the outyears. Features of the plan include buying the host systems for Silver Spring, Seattle-Sand Point, and Miami in FY 93; for La Jolla, Honolulu, Auke Bay in FY 94; and for Woods Hole, Seattle-Montlake, and Monterey in FY 95. However, if funding does not improve, the FY 94 and FY 95 systems will be delayed.

According to the draft plan, training systems and training courses are funded for all nine sites in FY 93-94 so that the whole agency can go through the learning curve at the same time. In late September or early October, each site will receive a training system, a CDC 9120 workstation for its training

facility. The CDC 9120, which has the identical operating system as the host system, is a 64-bit Silicon Graphics unit with Fortran, ORACLE, and EL*Awbus, a communication software for access to remote hosts. The training courses, provided in the IT-95 contract, will begin in FY 93 for the first three sites on their installed hosts and in FY 94 for the remaining sites on the CDC 9120.

Through the Center's staff meeting minutes, Dorothy Roll will inform the users at the Southwest Fisheries Science Center sites on the execution plans as they are formulated. When the details are firm, she will present an information seminar to the La Jolla staff. (D. Roll, [619] 546-7057)

PUBLICATIONS

Published

Alauddin, M., D. Squires, and C. Tisdell. 1993. Divergency between average and frontier production technologies: an empirical investigation for Bangladesh. Appl. Econ. 25:379-388.

Applied economic analysis and policy formation often relies on estimated production technologies. Primal representations of production technologies can be specified as the average production function or as the stochastic frontier. This paper uses nested and non-nested specification tests and assessment of economic variables, including elasticities and marginal products, to evaluate systematic differences between the average production function and three different specifications of the stochastic frontier. Bangladesh serves as an illustrative example. The importance emerges of first beginning any analysis of production technologies with nested hypothesis testing of inefficiency and non-nested hypothesis testing for systematic but unknown differences between the average and stochastic frontier functions followed by nested testing of the final form of the production technology.

Alvariño, A. 1991. Abundancia y distribucion batimetrica diurna y nocturna de los sifonoforos durante las cuatro estaciones del año 1969, en aguas de California y Baja California. Inv. Mar. CICIMAR 6(2):1-37.

The plankton collections were obtained with bongo nets of automatic open-closing devices. The tows were made day and night at the same locations at eight bathymetric levels, from 0 to 600 m deep, during the four seasons of 1969. Sixty-eight species of Siphonophora were obtained in these regions. This work includes only forty-nine species, because the study of *Chelophyes appendiculata, Muggiaea atlantica,* and *Eudoxoides spiralis* were published in Alvariño (1980; Proc. 4th Int. Coelenterates Conf., Sep. 1979; Interlaken, Switzerland), and sixteen species of the genus *Lensia* in Alvariño (1985; Inv. Mar. CICIMAR 2 [1]). In general, it was observed that most of the species inhabit deeper levels during daylight than at night; also, the eudoxia populations inhabited deeper strata than the polygastric populations. However, some siphonophores are able to swim throughout wide bathymetric strata, from the epi-, meso-, and bathypelagic zones. A table includes in detail for each species, abundance related to date, time, and depth of the haul for each location and season. Maps with the distribution of the stations, and profiles for each line of stations showing the levels at which plankton hauls were obtained are included for each season.

————————. 1992. Distribucion batimetrica, diurna y nocturna, de diez y siete especies de Quetognatos, durante las cuatro estaciones del año 1969, en aguas de California y Baja California. Inv. Mar. CICIMAR 7(1):1-169.

The species of Chaetognatha obtained with the open-closing bongo nets during stratified tows correspond to epipelagic and mesopelagic categories. The oblique tows extended day and night at same locations along lines 70.__, 90.__, 120.__ of the regular CalCOFI grid pattern. The depth strata occupied were, 0-25, 25-50, 50-75, 75-100, 100-225, 225-230, 350-475, 475-600 m depth. The Chaetognatha obtained may be included in various ecological categories, typical neritic species *(Sagitta euneritica), S. bierii* characteristic of the platform off California, widely distributed oceanic species flowing into this region (*Krohnitta subtilis, S. enflata, S. minima*), Central Pacific species (*Pterosagitta draco, S. bipunctata, S. hexaptera*), *S. pseudoserratodentata* characteristic species of the Northeast Pacific temperate waters, and *S. pacifica* and *S. neglecta* Indo-Pacific tropical species, the former extending also into the adjacent temperate waters, while the later is restricted to the warm tropical waters. Mesopelagic species, some of which inhabit also the bathypelagic strata were, *Eukrohnia bathyantarctica, E. bathypelagica, E. hamata, S. macrocephala, S. maxima, S. zetesios. Sagitta scrippsae* (indicator of the California Current), and the mesopelagic *S. decipiens* (indicator of upwelling) also present in the collections, have been previously studied (Alvariño, 1983, 1985). Tables for each species are included, showing the abundance of the species at port and starboard nets, and total for the day and night tows during the four seasons. Seasonal and day/night differences in distribution were observed. The most abundant species for 1969 was *S. bierii*, followed by *Sagitta euneritica, S. minima, S. enflata*, etc. *S. neglecta* was the rarest species in the collections. *Sagitta bierii* was most abundant in winter, spring and summer, while *S. enflata* was most abundant in the fall collections. Distributional transects for lines 70, 90, and 120 have been prepared for day and night collections during winter, spring, summer and fall for all the species observed. However, here are only presented those for the eight most abundant or characteristic species of the region. These profiles indicate the offshore and in-

shore flow of waters, the main center of distribution of the species, upwelling and submergence of populations. Thus, species from the central Pacific waters appeared more abundant at the far offshore locations, and the tropical or warm water Pacific species were more abundant at the southernmost offshore locations. Night and day variations in bathymetric distributions are at times also noted, indicating the effect of light and or changes in the ocean dynamics.

Bailey, K. M., R. D. Brodeur, N. Merati, and M. M. Yoklavich. 1993. Predation on walleye pollock, *Theragra chalcogramma*, eggs and yolk-sac larvae by pelagic crustacean invertebrates in the western Gulf of Alaska. Fish. Oceanogr. 2(1):30-39.

DeMartini, E. E., D. M. Ellis, and V. A. Honda. 1993. Comparisons of spiny lobster, *Panulirus marginatus*, fecundity, egg size, and spawning frequency before and after exploitation. Fish. Bull., U.S. 91:1-7.

Size-specific fecundities of spiny lobster, *Panulirus marginatus*, were compared for two time periods: pre- and early exploitation or "before" (1978-81), and postexploitation or "after" (1991). Fecundity was further evaluated within each time period at two collection sites that represented the major lobster fishing grounds (Maro Reef and Necker Island) in the Northwestern Hawaiian Islands. Complementary data on egg size and spawning frequency index were compared between study sites and time periods.

Study sites and time periods had no observable effects on egg size or spawning frequency, and there was no temporal effect on fecundity at Maro Reef. Fecundities at the two sites differed, however, and "after" size-specific fecundity was an estimated 16±9 percent greater than "before" fecundity at Necker Island. Observations suggest that the recent increase in fecundity at Necker Island may reflect a compensatory (density-dependent) response to greater exploitation at this site. Results are discussed in terms of evidence for density-dependent responses in other exploited spiny lobster stocks.

Finn, M., J. R. Henderson, B. L. Becker, and T. J. Ragen. 1993. The Hawaiian monk seal and green turtle at Pearl and Hermes Reef, 1990 and 1991. U.S. Dep. Commer., NOAA Tech. Memo. , NOAA-TM-NMFS-SWFSC-182, 29 p.

Lanfersieck J., and D. E. Squires. 1992. Planning models for individual transferable quota programs. Can. J. Fish. Aquat. Sci. 49(11):2313-2321.

This paper develops an approach to simulating markets for individual transferable quotas prior to their actual implementation. This approach is based on linear programming models for individual vessels that allow estimation of market derived demand for quota to simulate the expected equilibrium market price for quota and maximum quasi-rents for alternative quota allocations. The simulated price is an annual lease or rental price. The approach, applied to a sample of longline vessels targeting sablefish, *Anoplopoma fimbria*, in the Columbia International North Pacific Fisheries Commission area of the United States, indicates substantial potential gain in quasi-rent and economic efficiency from quota trade. The simulated quota exchange also indicates potential for concentration of quota. The quota market risks becoming thin, noisy, and hampered by noncompetitive forces, potentially requiring limits to quota transfer and concentration.

MacFarlane, R. B., E. C. Norton, and M. J. Bowers. 1993. Lipid dynamics in relation to the annual reproductive cycle in yellowtail rockfish, *Sebastes flavidus*. Can. J. Fish. Aquat. Sci. 50(2):391-401.

In yellowtail rockfish, *Sebastes flavidus*, lipids that accumulated in mesenteries and liver during the summer and early fall upwelling were subsequently translocated to developing ovaries during late fall and winter. Tissue and serum lipids were assessed by stage of ovary maturation from fish collected monthly over six annual reproductive cycles (1985-91) from Cordell Bank, a seamount off central California. Lipids were primarily transported to ovaries prior to fertilization. Energetic lipids (triglycerides, nonesterified fatty acids) were maximal in serum during yolk accumulation stages and declined significantly during embryonic stages. Between fertilization and parturition, lipid and protein content of ovaries declined by about 21 percent, a value approaching the minimum for lecithotrophy (that is, ovoviviparity). During gestation, however, serum phospholipids and calcium (vitellogenin surrogate) were significantly elevated relative to male levels, suggesting matrotrophic contributions. A reproductive mode that is primarily lecithotrophic but supplemented by maternal inputs during embryogenesis would be beneficial to viviparous fishes of the California coast. This strategy may optimize reproduction by coupling the disparate times of food abundance and gestations, yet allow for provision of nutrients late in the reproductive cycle should they be available.

Okihiro, M. S., J. A. Whipple, J. M. Groff, and D. E. Hinton. 1992. Chromatophoromas and related hyperplastic lesions in Pacific rockfish, *Sebastes* spp. Mar. Environ. Res. 34:53-57.

———. 1993. Chromatophoromas and chromatophore hyperplasia in Pacific rockfish, *Sebastes* spp., Cancer Res. 53:1761-1769.

Pacific rockfish from Cordell Bank, off central California (United States), were collected and histologically examined from 1985 to 1990. Hyperplastic and neoplastic cutaneous lesions, involving dermal chromatophores, were observed in five species: yellowtail rockfish, *Sebastes flavidus*; bocaccio, *S. paucispinis*; olive rockfish, *S. serranoides*; widow rockfish, *S. entomelas*; and chilipepper rockfish, *S. goodei*. Yearly prevalences were highest in *S. paucispinis* (29-38 percent). Prevalence was initially low in *S. flavidus*, but increased

more than three-fold from 1985 (7.5 percent) to 1990 (25 percent). The majority of lesions were black, but white, yellow, orange, red, and mixed-color variants were also seen. Lesions were found in skin, fins, lips, gingiva, tongue, urogenital papilla, conjunctiva, and cornea of the eye. Flat lesions were consistent with melanophore (black), xanthophore (yellow or orange), and erythrophore (red) hyperplasia. Neoplastic lesions included melanophoromas, amelanotic melanophoromas, xanthophoromas, erythrophoromas, and mixed chromatophoromas. Although etiology has not been determined, interest is currently focused on potential exposure to chemical and radioactive carcinogens from the Farallon Island Radioactive Waste Dump, 30 kilometers to the south.

Parrish, F. A., T. K. Kazama. 1992. Evaluation of ghost fishing in the Hawaiian lobster fishery. Fish. Bull., U.S. 90(4):720-725.

Perrin, W. F., and J. E. Heyning. 1993. Rostral fusion as a criterion of cranial maturity in the common dolphin, *Delphinus delphis*. Mar. Mammal Sci. 9(2):195-197.

Perryman, W. L., and M. S. Lynn. 1993. Identification of geographic forms of common dolphin, *Delphinus delphis*, from aerial photogrammetry. Mar. Mammal Sci. 9(2):119-137.

At least four morphologically distinct forms of common dolphins are found in the eastern Pacific. The scientists compared length data for common dolphins photographed from the northern, central, and southern regions as defined by Perrin et al. (1985) and found significant differences in average length for adult animals (>150 cm) and for "adult females," defined for our purposes as animals accompanied by calves. Analyses of calculated birth dates for calves demonstrated differences in timing of reproduction between the geographically adjacent forms. Length distributions from aerial photographs and samples collected from the purse-seine fishery were strikingly similar. This work demonstrates a new, noninvasive method for obtaining unbiased life history and morphological data.

Rogers, J. B., and E. K. Pikitch. 1992. Numerical definition of groundfish assemblages caught off the coasts of Oregon and Washington using commercial fishing strategies. Can. J. Fish. Aquat. Sci. 49(12):2648-2656.

Numerical definition of species caught together by the groundfish trawl fishery operating off the Oregon and Washington coasts during 1985-1987 indicated six major assemblages of species. Observers on commercial vessels recorded data allowing estimation of the weights of commercially important species caught in each tow. Assemblages were selected based on consistencies in three types of analysis of the species weights: detrended correspondence ordination, two-way indicator species clustering, and Bray-Curtis group average clustering. Two of the assemblages were dominated by a single species, one consisting largely of pink shrimp, *Pandalus jordani*, and the other primarily of widow rockfish, *Sebastes entomelas*. The other assemblages identified were a deepwater rockfish assemblage, a deepwater Dover sole assemblage, a nearshore mixed-species assemblage, and a bottom rockfish assemblage. These assemblages of commercially co-occurring species may be treated as units in developing mixed-species management plans. The deepwater rockfish assemblage identified in this study has not been previously described.

Segerson, K., and D. Squires. 1993. Capacity utilization under regulatory constraints. Review of Economics and Statistics 75(1):76-85.

This paper presents a methodology for predicting the effect of quota-type regulatory constraints on capacity utilization for a multiproduct profit-maximizing firm. The approach builds on recent advances in the use of virtual prices to model the effects of rationing. This allows the effects of regulatory constraints to be examined ex ante. The methodology is illustrated through a case study of the imposition of output quotas in an open-access marine fishing industry on the Pacific coast of the United States. The results suggest that, for certain species, output quotas can cause strong disinvestment incentives.

Somerton, D. A., and B. S. Kikkawa. 1992. Population dynamics of pelagic armorhead, *Pseudopentaceros wheeleri*, on Southeast Hancock Seamount. Fish. Bull., U.S. 90(4):756-769.

Watson, W., and H. J. Walker, Jr. 1992. Larval development of sargo, *Anisotremus davidsonii*, and salema, *Xenistius californiensis*, (Pisces: Haemuidae) from the Southern California Bight. Bull. Mar. Sci. 51(3):360-406.

Size series of 116 *Anisotremus davidsonii* (2.2-24.9 mm) and 131 *Xenistius californiensis* (2.2-41.7 mm) from field collections were examined for pigmentation, and most specimens were measured to determine morphometric characteristics. Subsets of 39 *A. davidsonii* (2.9-23.6 mm) and 25 *X. californiensis* (2.7-24.1 mm) were cleared and stained to examine skeletal development. Both species subsequently develop rather heavy dorsal and dorsolateral pigment; small juveniles display the longitudinal stripes that are well known in juvenile Haemulinae. Both species are moderately slender, with preanal length roughly half of body length. Development in both is gradual, with no marked changes in proportions. Both look like typical haemulines. Skeletal development differs little from that described for other haemulines. Bones of the jaws, operculum, and suspensorium are among the first to ossify, usually before notochord flexion. Ossification of neural and haemal arches and spines and vertebral centra, except the urostyle, is anterior to posterior. Pterygiophores and soft rays form first in the middle of the dorsal and anal fins in both species; addition is both anterior and posterior. Addition of dorsal spines begins posteriorly, but then may continue from anterior to posterior. Larval sargo and salema are distinguished from simi-

lar larvae off California and northern Baja California, primarily by a combination of myomere count and ventral pigment on the tail. Larval sargo typically have pigment on the peritoneum just anterior to the liver, while larval salema do not. Larval salema usually have a melanophore under the anterior hindbrain, while preflexion stage larval sargo usually do not. After notochord flexion, sargo are deeper-bodied than salema. Dorsal fin ray counts allow easy separation of postflexion and older sargo (14-15) from salema (12-13).

Wilson, C. D., and G. W. Boehlert. 1993. Population biology of *Gnathophausia longispina* (Mysidacea: Lophogastrida) from a central North Pacific seamount. Mar. Biol. 115:537-543.

Large numbers of the lophogastrid mysid *Gnathophausia longispina* were discovered in 1984 over Southeast Hancock Seamount on the northern Hawaiian Ridge. Additional specimens were collected from the same area during subsequent surveys in 1985, 1987, and 1988 to obtain new information on the life history of this species. Estimates of growth suggest that *G. longispina* reaches sexual maturity by its second year. Young are brooded by the female for nearly a year and released in late winter-early spring. It is doubtful if *G. longispina* live longer than 2 years or produce more than one brood. Most *G. longispina* are found within 100 m above the seamount summit. The modal progression of size classes over time indicates that this species is dependent on local processes rather than recruitment from other areas to maintain its populations at the seamount.

Yoshimoto, S. S., and R. P. Clarke. 1993. Comparing dynamic versions of the Schaefer and Fox production models and their application to lobster fisheries. Can. J. Fish. Aquat. Sci. 50(1):181-189.

Approved by Science and Research Director, SWR

Aquirre, A. A., G. H. Balazs, B. E. Zimmerman, and T. R. Spraker. Evaluation of Hawaiian green turtles, *Chelonia Mydas*, for potential pathogens associated with fibropapillomas. For consideration for publication in Journal of Wildlife Diseases.

Atkinson, S., B. L. Becker, T. C. Johanos, J. R. Petraszek, and B. C. S. Kuhn. Reproductive morphology and status of female Hawaiian monk seals, *Monachus schauinslandi*, fatally injured by adult male seals. For consideration for publication in Journal of Reproduction and Fertility.

Balazs, G. H. Homeward bound: Satellite tracking of Hawaiian green turtles from nesting beaches to foraging pastures. For consideration for publication in Proceedings of the 13th Annual Symposium on Sea Turtle Conservation and Biology.

Herrick, S., I. Strand, D. Squires, M. Miller, D. Lipton, J. Walden, and S. Freese. Application of benefit-cost analysis to fisheries allocation decisions: The case of Alaska pollock and cod. For consideration for publication in North American Journal of Fisheries Management.

Hobson, E. S. Trophic relations in the evolution of acanthoptergian fishes of warm-temperate coastal communities in the northeastern Pacific. For consideration for publication in Environmental Biology of Fishes.

Ito, R. Y., D. R. Hawn, and B. B. Collette. 1993. First record of the butterfly kingfish *Gasterochisma melampus* (Scrombridae) from the North Pacific Ocean. For consideration for publication in Fishery Bulletin, U.S.

Jacobson, L. D., N. C. H. Lo, and J. T. Barnes. Biomass dynamics of northern anchovy during the 1963 to 1991 seasons. For consideration for publication in Fishery Bulletin, U.S.

Moser, H. G., R. L. Charter, P. E. Smith, N. C. H. Lo, D. A. Ambrose, C. A Meyer, E. M. Sandknop, and W. Watson. Early life history of sablefish, *Anoplopoma fimbria*, off Oregon and California with application to biomass estimation. For consideration for publication in NOAA Technical Report NMFS.

Perryman, W. L., and M. S. Lynn. Examination of stock and school structure of striped dolphin, *Stenella coeruleoalba*, in the eastern Pacific from aerial photogrammetry. For consideration for publication in Fishery Bulletin, U.S.

Polovina, J. J., G. T. Mitchum, N. E. Graham, M. P. Craig, E. E. Demartini, and E. N. Flint. Physical and biological consequences of a climate event in the central North Pacific. For consideration for publication in Science.

Ragen, T. J., and G. A. Antonelis. The early phase of northern fur seal pup migration from St. Paul Island, Alaska. For consideration for publication in Marine Mammal Science.

Squires, D. Sources of growth in marine fishing industries. For consideration for publication in Marine Policy.

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La Jolla, California

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